United States
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Guide for Uprating REA Transmission Structures for Higher Operating Voltages

FOREWORD

REA Bulletin 62-7, "Guide for Uprating REA Transmission Structures for Higher Operating Voltages," provides engineering personnel with information on the possibilities of adapting existing lines for use at higher voltages.

In addition to electrical and structural design aspects, the publication includes numerous drawings, illustrations, and material lists for suggested structure modifications.

Uprating transmission lines to higher operating voltages should not be construed as a substitute for all new construction. Rather, it should be considered as a means of solving specific problems by making better utilization of existing resources.

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REA BULLETIN 62-7

GUIDE FOR UPRATING REA TRANSMISSION STRUCTURES FOR HIGHER OPERATING VOLTAGES

RURAL ELECTRIFICATION ADMINISTRATION

U.S.DEPARTMENT OF AGRICULTURE

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SECTION I

INTRODUCTION

The increasing demand for power, coupled with the difficulty in obtaining new rights-of-way dictates that the possibility of uprating the capacity of an existing line be considered. In uprating the capacity of a line, the possible options include installing a larger conductor on existing structures, increasing the operating voltage, or a combination of both.

In general, environmental problems will be less in uprating an existing line than obtaining right-of-way for a new facility; however, uprating is not necessarily the correct or only solution for increased demand problems.

The primary purpose of this manual is to furnish engineering information for use in uprating standard REA wood pole-type transmission lines in the 69 kV to 230 kV range. This publication is not intended to supersede REA Bulletin 62-1 "Design Manual for High Voltage Transmission Lines" or any part thereof for designing new transmission facilities; however, it does provide guidance on possible structure modifications and certain special design criteria for uprating existing lines while maintaining REA Grade-B construction for transmission lines.

The information is presented in the form of new structure drawings, referenced to existing drawings in Form 805, with suggested material lists for the new structures, applicable tables, examples, and a general narrative on uprating of lines. A sample uprating Design Study is included for reference.

It is the responsibility of the borrower or their engineer to fully investigate the feasibility of a given uprating project based on system load requirements, sound design practices, economics of construction and operation, and environmental considerations.

It should be clearly understood that several of the specific structure uprating concepts represented by the drawings in this publication must be considered experimental in nature. In addition, a number of the structures suggested may lack any significant previous operating experience and have probably not been tested to determine actual structural capabilities.

As these structures are used in uprating projects, field experience may indicate the desirability to change or modify some of the hardware items. It is important that REA be kept informed of any such changes to facilitate drawing modifications or alternatives in future bulletin revisions.

SECTION II

CONSIDERATIONS TO BE MADE IN LINE UPRATING

An electrical power system is a complex of individual generating stations, transmission arteries, voltage reduction points and distribution service lines. The transmission and distribution line grids of most power systems have evolved over many years time to meet developing load demands. Many of the power lines were constructed to meet specific system needs without coordinated long-range studies of system development.

Practically every power system has found itself in the position of needing to upgrade a critical transmission line to a higher power transfer capability. Once this need has been recognized, one of the first questions to arise is, "Is there anything that can be done to the existing line to meet the new system requirements?" In many cases, the existing line can be uprated; however, a hasty decision made one way or another may result in an expensive temporary solution to a system load problem that might have other long-term solutions.

A. System Requirements

Every transmission line upgrading should be evaluated for adherence to system reliability and planning criteria. The prime tool in performing this type of evaluation is a system load-flow study.

In addition, some basic analysis can be done using REA Bulletin 62-5, "Electrical Characteristics of REA Alternating Current Transmission Line Designs." This publication provides a means for hand calculations of individual transmission line performance parameters and approximations of power transmission capabilities, line voltage drop, and power losses.

Another type of analysis which is useful in evaluating transient system conditions is the Transient Network Analyzer (TNA). This analysis technique includes all non-linear circuit components such as transformers, lightning arrestors, and load switching devices. The TNA is used to study many items including the following:

1. Switching and reclosing transients.

2. Resonance overvoltages.

3. Effects of shunt reactors/transformer tertiary windings.

4. Surge arrestor parameters.

5. Transient recovery voltage.

6. Effects of preinsertion resistors.

7. System Operating Conditions/Sequences.

Using one or more of the types of analyses described above, certain essential parameters of the proposed uprated or converted transmission line should be defined, namely:

1. Operating voltage.

2. Line current.

3. Proposed conductor size.

4. Maximum operating conductor temperature.

Other parameters may also be established but these four are essential for transmission line analysis.

Table II-1 provides a list of minimum conductor sizes for various operating voltages.

TABLE II-1
REA MINIMUM CONDUCTOR SIZES(1)

kV_{LL}	ACSR(2)	6201(2)
34.5	1/0	123.3 kcmil
46	2/0	155.4 kcmil
69	3/0	195.7 kcmil
115	266.8 kcmil	312.8 kcmil
138	336.4 kcmil	394.5 kcmil
161	397.5 kcmil	465.4 kcmil
230	795 kcmil	927.2 kcmil

(1) The above minimum sizes are based on mechanical, corona and radio interference considerations. Larger conductors may very often be required because of the economics of power losses and other factors.

(2) On an individual uprating case basis, conductors may be considered which are one size less than that listed above for the total stated line voltage.

B. Electrical Clearance Requirements at Uprated Voltage

1. Clearance to Support.

The analysis of structure uprating assumes conformity to the electrical clearances defined by REA Bulletin 62-1. Where the Bulletin is silent on clearances, the National Electrical Safety Code or local code, if more stringent, is to be utilized.

2. Right-of-way Width

One of the most important electrical clearance requirements is sometimes overlooked in procuring of right-of-way easements for transmission lines. The width of right-of-way required for a transmission line depends upon many factors, such as:

a. Structure configuration (phase spacing).

b. Conductor size and weight.

c. Structure span length.

d. Amount of conductor sag.

e. Amount of conductor blow-out.

f. Operating voltage.

g. Elevation (MSL).

All of these factors, and more, should be considered before a transmission line is uprated or converted. Figure II-1 illustrates a typical 115 kV TH1-AAX structure. An example of a right-of-way width calculation follows:

Given: Ruling span = 226.8m (750')
Operating voltage = 115 kV (121 kV max. oper. voltage)
Conductor = 477 MCM 26/7 ACSR
Sag at 60° final tension = 5.12m (16.8')
Wind = 26.7 N (78.9 km/hr) (6# [49 mph]) = 6.26 N/m (0.4290#/lineal ft.) = W
Cond. bare weight = 9.58 N/m (0.6566#/ft.) = V
Wt. of insulator string = 347.0 N (78#)
Length of insulator string = 1.195m (3.92 ft.)
Mean sea level elev. = 1838m (6,030')

Vertical span = 221m (725') = VS
Horizontal span = 228.6m (750') = HS

Calculate the minimum required right-of-way width.
Let blow-out angle = θ

$$\theta = \tan^{-1} \frac{HS \times W}{VS \times V + WI/2}$$

$$\theta = \tan^{-1} \frac{(228.6)\ (6.26)}{(221)(9.58) + 347/2} = 31.99° \quad \text{(Metric)}$$

$$\theta = \tan^{-1} \frac{(750)\ (0.4290)}{(725)(0.6566) + 78/2} = 31.99° \quad \text{(English)}$$

Blow-out angle θ = 31.99°
Horizontal displacement of sag = 1.195m + 5.12m (3.92' + 16.8') Sin 31.99° = 3.35m (10.98')
Calculate the minimum clearance to buildings located on the edge of right-of-way:

Basic clearance (per NESC Fig. 234-1) = 3.05m (10.00')

Voltage adder: (Metric)

$$\frac{([121\ \text{kV}/\sqrt{3}\,] \quad -50\ \text{kV})\ (1.02\ \text{cm/kV})}{(100\ \ \text{cm/m})} = .20\text{m}$$

Voltage adder: (English)

$$\frac{[(121\ \text{kV}/\sqrt{3}\,] \quad -50\ \text{kV})\ (.4\ \text{in./kV})}{(12\ \text{in./ft.})} = (0.66')$$

Altitude adder: (Metric)

$$\frac{(1838-1006)\ (.2)\ (3\%)}{304.8} = .02\text{m}$$

Altitude adder: (English)

$$\frac{(6030'-3300')(.66)(3\%)}{1000'} = (0.05')$$

Total = 3.27m (10.71')

Minimum right-of-way width required =
2 (Hor. phase spacing + hor. sag displacement + Clearance to Bldgs.)
Min. right-of-way width required =
2(3.81m + 3.35m + 3.26m) = 20.84m
2(12.5' + 10.98' + 10.71') = (68.38')

Note: The 20.84m (68.38') width is the minimum allowable value. Spans in excess of 228.6m (750 ft.) will require additional width.

The following list of nominal right-of-way widths have been generally proven to be satisfactory and, in most instances, provide sufficient clearance for a fallen structure to remain within the right-of-way.

	Nominal Line Voltage in kv_{LL}				
	69	115	138	161	230
Right-of-Way Width in Meters	22.9-30.5	30.5	30.5-45.7	45.7	45.7-61
(Width in Feet)	(75-100)	(100)	(100-150)	(100-150)	(150-200)

3. Right-of-way Easements

It should be noted that a borrower may have owned and operated a 69 kV transmission line within a 30.5m (100 ft.) easement for the past several years and yet this same 30.5m (100 ft.) easement will not be sufficient for operating at a higher voltage. The following list is provided to assist the borrower and engineer foresee some of the common problems of reusing existing right-of-way.

a. Some easements may have been purchased by structure locations and/or line configuration, thus in some localities any change in the configuration or relocation of individual structures may require renegotiating the easement.

b. The centerline of construction does not always correspond to the centerline of the easement.

c. Some easements do not specify the right-of-way width, thus legal counsel will be required to determine the right-of-way status for uprating the line.

d. Do not overlook or confuse "permanent easements" with "easements for construction."

e. Encroachments may conflict with any type of line uprating.

(1) Buildings constructed on or near an existing line may be located such that horizontal and vertical clearances are impractical to maintain. Examples: houses, barn, shed, portable building on a permanent foundation, windmill, TV or radio antenna, etc. In many instances, once the permanent facility is built within the easement and maintains "Code Clearance" to the line, the Borrower cannot force the landowner to move the facility.

(2) Ponds - specifically the location and height of the dam.

(3) New roads and/or driveways, public and private.

(4) In some areas a change in land use should be considered an encroachment. Example: rural undeveloped to producing farmland. This would cause concern in providing vertical clearance for the expected use of large combines and/or heavy equipment.

(5) Sprinkler systems.

(6) Utility or communication facilities added since the construction of the transmission line.

(7) Commercial signs.

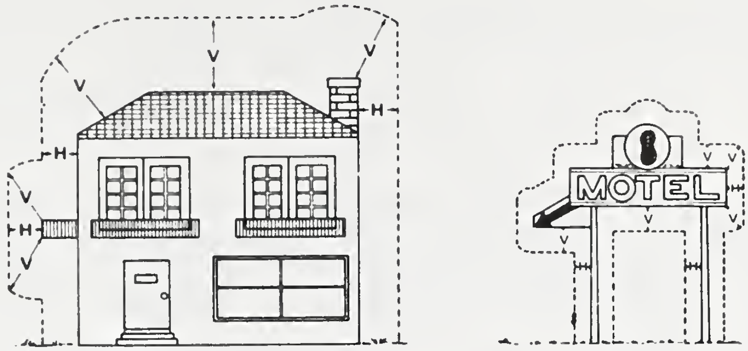
(8) Children's Tree House - Permanent type mounted on wood poles for example.

f. Easements may contain limitations on tree clearing and/or line accessibility.

g. "Blanket Easements" should be reviewed by legal counsel.

h. Line modification might be limited due to the construction of airstrip facilities or Radio/TV transmitter built nearby since the original line was constructed.

FIGURE 234-1
CLEARANCE DIAGRAM

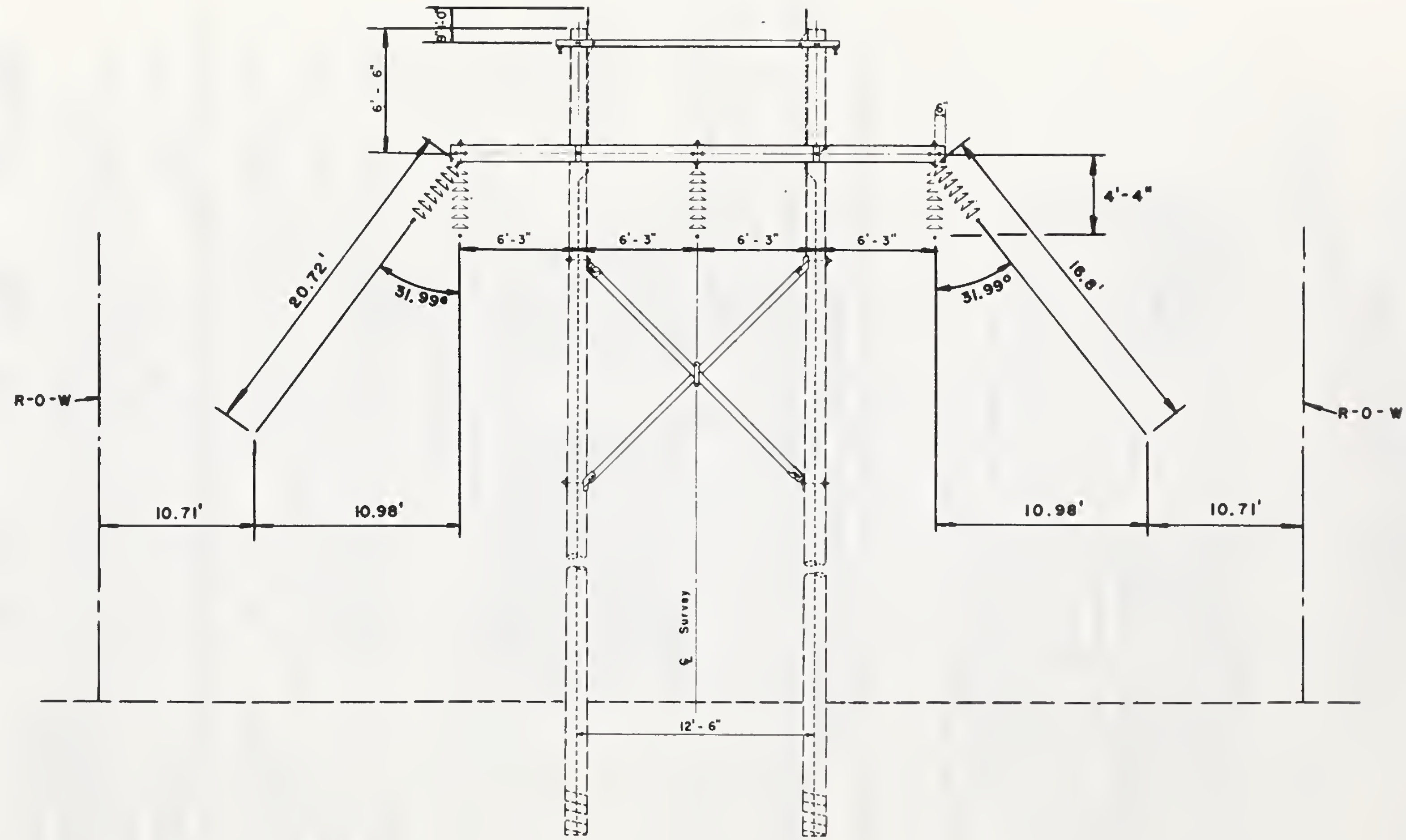


V=MINIMUM VERTICAL CLEARANCE, MEASURED EITHER DIAGONALLY OR VERTICALLY.
H=MINIMUM HORIZONTAL CLEARANCE.

Table 234-1. Clearance of Supply Wires, Conductors, and Cables Passing By But Not Attached To Building and Other Installations Except Bridges

(Voltages are phase to ground for effectively grounded circuits and those other circuits where all ground faults are cleared by promptlv de-energizing the faulted section, both initially and following subsequent breaker operations. (See the definitions section for voltages of other systems.)

			Supply line conductors, street lighting conductors, and service drops			
	Communication conductors and cables, guys, messengers, lightning protection wires, neutral conductors meeting Rule 230E1, supply cables of all voltages meeting Rule 230C1, and supply cables of 0 to 750 V meeting Rule 230C2 or 230C3		Open supply line conductors 0 to 750 V, and supply cables over 750 V meeting Rule 230.C.2 or 230.C.3		Open supply line conductors 15 to 50 V	
Clearance of	m	(ft)	m	(ft)	m	(ft)
Buildings						
Horizontal						
To walls and projections	.92	(3)	1.5	②①(5)	3.1	③(10)
To unguarded windows	.92	(3)	1.5	②①(5)	3.1	(10)
To balconies and areas accessible to pedestrians④	.92	(3)	1.5	(5)	3.1	(10)
Vertical						
Above or below roofs or projections not accessible to pedestrians	.92	(3)	3.1	(10)	3.7	(12)
Above or below balconies and roofs accessible to pedestrians④	2.5	(8)	4.6	⑥(15)	5.2	(17)
Above roofs accessible to vehicular traffic	5.5	(18)	5.5	(18)	6.7	(22)
Signs, chimneys, radio and television antennas, tanks, and other installations not classified as buildings or bridges⑤						
Horizontal	.92	(3)	1.5	①②(5)	3.1	③(10)
Vertical above or below	.92	(3)	1.5	①(5)	3.1	(10)



BASIC STRUCTURE: THI-AAX

FIG. II-1

(METRIC) MINIMUM R-O-W REQUIRED: 477 MCM 26/7, 228.6 m. R.S., 15.6°C., 26.7 N. WIND = 2(3.81 + 3.35 + 3.26) = 20.84 m.
(ENGLISH) MINIMUM R-O-W REQUIRED: 477 MCM 26/7, 750' R.S., 60° F., 6 LB. WIND = 2(12.5 + 10.98 + 10.71) = 68.38'

C. Analysis of Existing Lines and Structures

Engineering analysis has determined that several types of standard REA structures can be converted or uprated to higher line voltages. The structures which have been reviewed are the single-pole structures TS-1, TS-1X, and TSZ, and two-pole structures TH-1, TH-1A, and TH-10. Each of these structures will be analyzed separately in Sections III and IV.

Before an existing structure or line becomes a feasible candidate for voltage conversion or uprating, a thorough records search must be made, detailed field information obtained, and comprehensive engineering calculations made.

1. Review of Existing Line Parameters.

An in-depth review of the design parameters and construction methods used for the existing transmission line must be conducted at the beginning of any proposed line conversion or uprating project. The purpose of such a thorough study is to clearly define the starting point and configuration before becoming committed to an expensive, time-consuming line modification.

Several essential facts about the existing facilities must be ascertained:

a. What basic design criteria was used: (If NESC, which Edition?) REA Bulletin 62-1? Is the original design data book available? What specific overload factors were used?

b. What basic electrical clearances (horizontal and vertical) were used in the original design? Are original construction drawings/contract documents available? Are existing plan and profile drawings up to date? Has line had foot patrol to detect right-of-way encroachments; heights and locations of all utility crossings; changes in ground elevations (cuts/ fills); pole heights, classes, and locations correct as shown on plan and profile drawings; are all highways, streets, railroads accurately shown? Have any airports or radio/TV stations been built in the general area since the original line construction?

c. Do the existing structures individually have any surplus strength capabilities? What standard was used in pole setting depth? Is the ground line circumference in excess of the minimum dimension for the ANSI pole

class? Is the wind span for the individual structure less than the maximum allowed for pole strength capabilities or uplift limitation?

2. Uprating/Converting Using Existing Structures.

After establishing the need for system and transmission line upgrading, the problem of right-of-way width and clearance requirements were considered. In the previous section, some items of review were suggested to help determine whether the existing structure configurations have any significant strength or electrical clearance parameters in excess of that required by the NESC or REA Bulletin 62-1.

If, in fact, the existing structures are found to have certain strength or height advantages, an uprating or conversion may be possible with a minimum of expense involved in material and construction. Some of the methods of line modification that would fall into this category are:

a. Install larger conductor.

b. Bundle smaller conductor (vertical or horizontal bundle).

c. Install conductor with less sag or install conductor with more tension and install vibration dampers.

d. Use existing conductor at higher voltage.

Each of these methods of line modification must be examined individually, as each has problems that are peculiar to it.

Removing existing conductors and installing a single larger conductor may be a valid line modification technique, provided the existing structures have adequate pole strength and ground clearance to accommodate the increase in vertical and horizontal loads and increased conductor sag.

Bundling conductors to achieve voltage upgrading may be a valid technique. This method of line modification lends itself to structures that have excessive pole strength in their present configuration. Sufficient ground clearance will be required to offset any increase in insulator string length and basic voltage clearance requirements.

Horizontal conductor bundles usually consist of two conductors per bundle at voltages less than 345 kV. The horizontal bundle method minimizes the amount of additional ground

clearance required for voltage upgrading because the same wire size and resulting conductor sag may be utilized. One disadvantage to this technique is that a new conductor cannot be added to form a horizontal bundle with an existing conductor (even if they are the same size) because of the difference in initial and final conductor sag and tension values.

Vertical conductor bundles may be utilized in most of the same situations as the horizontal bundle. The vertical bundle arrangement requires about 30.5cm (12") to 35.6cm (14") more height at the conductor attachment point than the horizontal bundle, due to the length of the conductor hanger. There are some advantages to the vertical bundle technique. One advantage is that a new conductor can be installed in the top position of a vertical bundle and the existing conductor installed in the lower position. Another advantage is that vertically bundled conductors may be installed on certain single-pole structures (e.g., line post construction).

Another method of line upgrading/conversion utilizes the installation of a conductor which has certain vibration damping characteristics. Conventional ACSR conductor may also be installed with higher line tension and vibration dampers. Both of these techniques operate on the principle that a larger conductor may be installed but at considerably higher line tension and less sag. The existing tangent structures, however, must be capable of withstanding the increased vertical and transverse loadings.

Utilizing new or different conductor configurations will result in different galloping conductor ellipses. The revised configuration should be analyzed in the maximum, minimum, and ruling spans to determine whether the conductors will overlap during galloping conditions.

Some structures may be upgraded/converted to higher voltage levels by raising the shield wire on a type of bayonet and installing new or modified crossarms or conductor attachment points to higher positions. Structures that may be modified in this manner must have a considerable amount of excess pole strength in their present configuration. Raising the shield wire and conductor locations will greatly increase the ground line moment and other structure loadings. If the existing conductor is to be utilized at a higher operating voltage, it must be capable of conveying greater electrical loading.

D. <u>Insulation Levels</u>

1. Lightning - In general, the shield angle should be 30°; however, the shield angle may be increased to 40° based on the line's loading, reliability, and the system integrity required by the individual line being uprated.

2. Horizontal Post Insulators - Unless otherwise specified a BIL will be required approximately 20% above code dry flashover.

3. Suspension Insulators, 115 kV - 230 kV. Generally, all insulator strings are to conform to the drawing TM-1 of the REA Form 805; however, one bell less than standard may be used if the following criteria are met:

a. The line has an overhead groundwire.

b. The pole ground resistance is less than 10 ohms.

c. The line is located in moderate isokauranic levels.

d. The line has no contamination problems.

E. <u>Consider Cost Factors</u>

The considerations to be made in transmission line uprating, up to this point, have dealt mainly with system operational requirements, electrical clearance requirements, and structural performance capabilities. Information presented in this section will direct our attention to expenditures of resources involved in line conversion and uprating. These expenditures include finances, time, manpower, environmental, and material, to note only a few.

1. Additional Right-of-Way.

Perhaps the most important questions to be resolved in any proposal for line uprating or conversion concern the right-of-way affected by the line changes. The method of calculating the minimum required right-of-way width for the proposed uprated structure was described in Section II-B.

Another critical question concerning right-of-way is, "Can additional and adjacent right-of-way width be obtained at all?" If the existing line route crosses predominantly rural countryside, the chances are good that additional/adjacent right-of-way can be obtained. If, however, the existing line route crosses a developing residential area or is restricted

by other existing rights-of-way or geographical features, it may be virtually impossible to obtain additional/adjacent right-of-way; in that case, alternate methods of line construction must be considered, e.g., tear down and rebuild on existing right-of-way width.

If the owner concludes that the additional/adjacent right-of-way width can be obtained, the next question to be encountered is, "What will the additional right-of-way cost in terms of time and money?" Experience has proven that right-of-way negotiations, settlements, and condemnation actions require considerably more time and money to acquire than is first anticipated.

It is suggested that an assessment of real estate values and properties affected by the line conversion be made by a private real estate broker or registered land appraiser. It is further suggested that neighboring cooperatives and public utilities be contacted to gain information concerning their recent experience in time and expense involved in right-of-way procurement or condemnation proceedings.

A firm commitment to proceed with line uprating or conversion should be withheld until the owner is satisfied with the accuracy and adequacy of answers to the questions concerning additional right-of-way.

2. Material Costs.

The cost of material involved in the proposed line conversion or uprating should be studied. There are at least three significant items that must have value assessments made or derived. The first is the "book" value of the existing structure, items, or wires that will be affected by the line modification or retirement. (This may be deduced from the property accounting records.) Secondly, the salvage value of the removed materials must be estimated or otherwise defined. (This value should be entered as a deduct item when estimating the total project cost.) Thirdly, the cost of the material to be installed must be defined in order to establish new structure costs for property accounting records.

Another item that should be considered is the availability of the types of material being considered for use in the proposed conversion or uprating. Material lead time varies in an unpredictable manner; therefore, the designer should check the supply or availability of materials needed in the time frame planned for line conversion. Items such as

horizontal line post insulators, long-assembled crossarms, and armor grip suspension units are usually long lead time items, and their acquisition may have a bearing on project planning.

3. Labor Costs.

The labor cost to convert or uprate the proposed transmission line will probably be the most significant expense item in the project. The amount of time and labor activities required in a line conversion will be substantial. Labor costs may be several times as great as material costs.

The categories of labor costs that must be identified and tabulated are the labor to: remove specified items of existing line materials and dispose of as directed; modify/revise existing structures; install new line materials; clear additional right-of-way.

4. Technical Analyses.

A complete analysis of the existing transmission line must be performed. An expense item involved in the uprating or conversion project are the activities involved in such analyses. The costs should include the time and expenses for the activities listed below.

Record Search - A complete search of design records, drawings, and property records to determine the criteria used in design and construction of the existing line.

Field Inspection - A complete and detailed inspection of the existing transmission line must be performed, including foot patrol, pole inspection, plan and profile verification, right-of-way encroachment inspection, pole height verification, pole groundline circumference measurements, etc.

Engineering Analysis - Design analyses of the existing line and the uprated structure must be performed including structure strength and hardware analysis, conductor galloping, electrical clearances, computation of overload factors, verification of accurate engineering drawings, etc.

5. Compare Alternatives.

The information presented in this section has attempted to provide various concepts of structure and line modifications. Each of the available methods of line conversion or uprating will involve differing expenditures for materials, labor, right-of-way, engineering analysis, etc. It is important, therefore, to prepare comprehensive cost estimates for each of the configurations to be considered for the uprating project.

The project estimate should itemize all significant cost items involved in each proposed structural configuration. All deductible returns for salvageable materials, etc., should be itemized as cost reduction entries.

After each proposed structure configuration has been studied and a project estimate prepared the potential uprating structures should be ranked by their total adjusted or net cost. The structural configuration which results in the least estimated project cost is usually the most likely one to be constructed.

SECTION III

DETERMINING THE BEST SOLUTION

A. Consider Intangible Factors

In developing any system improvement, there are a multitude of factors to evaluate. Some of these are intangible items and thus cannot be meaningfully evaluated in monetary terms.

Two such factors are consumers' interests and public relations. The old adage which says, "Whatever is good for the customer is good for the business," seems appropriate. Reliability of service and consumer interests are obviously related; therefore, when system analyses conclude that line conversion or uprating is necessary to provide the desired reliability of service, the consumers' interests are being supported, and the project warrants careful consideration.

Maintaining good public relations is a desirable posture for any organization. A proposal to utilize existing transmission line rights-of-way for needed system improvements certainly is an attempt to develop good public and consumer relations. Therefore, the uprating or conversion of existing transmission lines within existing rights-of-way or minimal increases in rights-of-way width is in the best interests of the general public.

B. Consider Tangible Factors

When considering tangible factors concerned in line conversion or uprating, an obvious one is the total estimated cost of the proposed project. As described earlier, the estimated cost for each alternative method of line conversion should be carefully prepared. The estimated cost of a totally new transmission line on totally new right-of-way may also be prepared for comparison of cost and public interest.

A second tangible factor is the time element available to provide the needed system modifications. If increased power requirements or system service is required and the time available to construct these system improvements is very limited, then the modification of existing power lines on existing rights-of-way can be a very tangible asset.

A third tangible factor is the electrical system capability. If additional service is needed, or requested, in a part of the system which has marginal or limited capabilities, the necessity for system improvement becomes a tangible factor.

C. Select Between Alternatives

After objectively comparing the various factors described above, the best overall solution to the problem of line conversion or uprating should become obvious. Certainly minimizing construction costs is important. But perhaps the need for system improvements is so critical that an emergency situation exists, and then construction costs become of less importance.

Each situation must be evaluated independently and conscientiously. When this is done, the owner can objectively determine the best solution for their system's needs and be confident that the interests of his consumers and the general public are also being served.

D. Typical Line Problem

A borrower has operated and maintained 20.92 kilometers (13 miles) of 69 kV transmission line, radial feed, that serves a 69/12.5 kV substaton with six distribution feeders. The transmission line utilizes H-frame TH-1G structures with 266.8 (26/7) ACSR conductors and 2-3/8" H.S. steel shield wires constructed within a 30.48m (100 ft.) wide easement. The "Long-Range Planning" specifies the need to convert the distribution feeders to 14.4 kV and the transmission/substation facilities to 138 kV with 795 (26/7) ACSR conductors and relocate the "source tapped" (G & T Substation).

The initial investigation reveals the following facts:

1. It is currently the month of July with present peak loads already at the system's maximum capability with only a small unbalanced condition, thus, in-service for the 138 kV operation will be required with eleven months.

2. Alternative sources for the distribution loads are not available or they are impractical for long-term operation.

3. The weak link in the transmission/substation system is the 266.8 conductor. The 69/12.5 kV transformer has additional capacity for the distribution loads and space was provided for two additional 12.5 kV feeders.

4. The right-of-way contains numerous new crossings and encroachments, (utility, public, and private).

5. Part of the easements have been purchased by structure location and with limited right of access.

6. A metal plating company and railroad spur have since been located along .8km (1/2 mile) of this line.

7. The extremely harsh winters of unusually heavy ice have made construction impractical from November through January for the past four years.

8. The Original line was designed with 198m (650 feet) ruling span, 274m (900 feet) maximum span, a conductor operating temperature of 48.9°C (120°F) hot and -17.8°C (0°F) cold, a basic structure of 60 feet Class 2 poles, one crossarm with some structures being X-braced and the conductors were attached with AGS units. Dampers were not required as the 266.8 ACSR conductor was installed at a moderate tension. It was placed in service nine years earlier.

9. The profile drawings are incomplete and all other design data has been lost.

10. Operations records show a high outage rate due to lightning, trees, and galloping conductors.

11. The 69 kV line can be taken out of service only during periods of low demand.

The following preliminary options must first be reviewed before the actual uprating is to be considered.

1. Determine all other feasible routes on both public and private properties. This shall include right-of-way widths of 15.24m (50 feet), 22.86m (75 feet), and 30.48m (100 feet) and a cost/mile for each.

2. Determine the relative cost of "new" single pole and H-frame construction with 795 (26/7) ACSR conductors.

3. Determine the feasibility of expanding the 69/12.5 kV substation by adding a second 69 kV line, possibly loop feed.

4. Determine the cost of removing the existing line and building a new line in its place.

5. Determine if another conductor, 477 (26/7) ACSR or 636 (26/7) ACSR, can be used at 100°C (212°F) operation and what are the losses.

Now let's assume that all indications have now resulted in a common proposal, namely that the existing line will have to be converted to 138 kV on the existing right-of-way, with a minimum available outage time, using the same structure locations and reconductoring with 636 MCM 26/7 ACSR conductor to be operated at 100°C (212°F).

In general, the specific structure for this conversion is chosen for the following reasons:

(1) It must be compatible with hot-line work and/or working above energized lines.

(2) It must provide additional crossarm and structure strength.

(3) It must provide substantial increase in ground clearance to go from 266.8 conductor at 48.9°C (120°F) operation to 636 conductor at 100°C (212°F). If this becomes a governing factor as the detailed design progresses, consideration will have to be made as to the use of self damping conductors and/or installing dampers on tightly strung 636 (26/7) ACSR.

In Summary - The TH-1G to TH-VS (69 kV to 138 kV) conversion structure would be recommended for the detailed design considerations. Throughout the detailed design, the Engineer must be aware of specific individual structure locations that cannot be converted by the use of this structure or any other structure in this presentation. Those unique locations will require special design considerations and/or the total replacement with standard REA transmission structures.

SECTION IV

CONVERTING STANDARD REA STRUCTURES

Several of the standard REA transmission structures are capable of being modified to such a degree that they may operate at higher line voltages. Table IV-1 provides a listing of the standard structures considered for uprating and their uprated structure designations and voltages. The standard REA angle and deadend transmission structures have not been considered as part of this presentation. Due to the critical conductor spacing, insulator swing requirements, pole loading and the increased guy tensions of a modified angle or deadend structure, it is recommended that all angle and deadend structures of a proposed uprated line be replaced with standard REA structures at the appropriate higher voltage and increased spacing.

TABLE IV-1

INDEX OF UPRATED STRUCTURES

Original Standard Structure Designation	Uprated Structure Designation			
	69 kV to 115 kV	69 kV to 138 kV	69 kV to 161 kV	69 kV to 230 kV
TS-1	TS-1-HP TS-15-HP TH-1AM	 TS-15-HP TH-1AM	TM-10M	
TS-1X	TS-1X-HP TS-15X-HP TH-1AAXM	TS-1X-HP TS-15X-HP TH-1-AAXM	TH-10M	
TSZ-1	TSZ-1-HP TSZ-MPH TH-1A (Mod.)	TSZ-1-HP TSZ-MPH TH-1A (Mod.)	TH-10K	
TH-1	-	-	-	-
TH-1G	TH-VS TH-HPX TH-24A	TH-VS TH-HPX TH-24A	TH-161MT	

	115 kV to 161 kV	115 kV to 230 kV
TH-1A	TH-VS TH-HFS TH-161MV	
		161 kV to 230 kV
TH-10		TH-HFST TH-230MV

The conversion procedures noted below are intended as suggestions only. Each pole that is utilized for structure uprating must be inspected and evaluated on an individual basis. Not all poles will be suitable for use in structure uprating; in those cases where poles are damaged or deteriorated to such a state that they are unusable, the poles must be replaced. If the existing poles are judged by the owner's inspector to be usable, it is expected that all unused holes will be plugged with treated plugs and that reasonable repair or maintenance will be made to the pole as well as the existing conductors and shield wires.

TABLE IV-2

VERTICAL CLEARANCE COMPARISONS

		69 kV	115 kV	138 kV	161 kV	230 kV
New REA 62-1 @ 75°C (167°F)						
Cult. Fields	(m.)	7.01	7.32	7.48	7.62	7.93
	(ft.)	(23)	(24)	(24.5)	(25)	(26)
Old REA 62-1 @ 48.9°C (120°F)						
Cult. Fields	(m.)	6.40	7.01	7.32	7.62	7.9
	(ft.)	(21)	(23)	(24)	(25)	(26)
Along Rural Roads	(m.)	7.01	7.62	7.93	8.23	8.5
	(ft.)	(23)	(25)	(26)	(27)	(28)

Example: An existing 115 kV line designed to the Old REA 62-1 Bulletin vertical clearance category "Along Rural Roads" could be uprated to 161 kV under the new REA Bulletin 62-1 (File with) which requires 7.62m (25 feet) of vertical clearance over "Cultivated Fields."

To compensate for increased conductor sag at 75°C (167°F), the conductor attachment height of the uprated line must be raised approximately .46-.61m (1½-2 feet).

SINGLE POLE STRUCTURE MODIFICATIONS

1. Uprating the TS-1

a. TS-1 to TS-1-HP (69 kV to 115 kV)

The basic TS-1 Structure (Figure 89) can be uprated to the TS-1-HP Structure (Figure 102) if certain criteria are met.

The TS-1-HP Structure provides a bottom conductor attachment location 2.97m (9'-9") from the pole top. Compared to the bottom conductor location on the TS-1 Structure, 3.73m (12'-3") from pole top, an increase in ground clearance of .635m (2'-1") (minimum) can be gained by the structure modification. This increase in ground clearance will be sufficient for voltage uprating to 115 kV, if, and only if, the original line design was based on a minimum vertical clearance of 7.01m (23'-0") (Old Bulletin 62-1 classification of "Along Rural Roads").

The TS-1-HP provides the top phase conductor with a shield angle of approximately 36° at the structure attachments. The conductor galloping performance of the uprated structure is as good as the original TS-1 structure with the same wire size.

The physical conversion of the structure may be achieved by: first, detaching the existing shield wire from the pole top and lowering it to rest on the upper crossarm or temporarily securing it to the side of the pole (leave suspension unit intact); second, installing the shield wire bayonet and top horizontal post insulator (the bottom bolt for the insulator passes through the bottom bolt hole of the bayonet); third, lift shield wire and existing suspension unit and secure it to the bayonet top with a Y-clevis eye, then lift the top phase conductor and existing suspension unit and hang it from the top insulator with an anchor shackle; fourth, remove the upper crossarm and brace; fifth, install the middle horizontal post insulator; sixth, detach the lower phase conductor (on the side with the middle horizontal post insulator installed), leave the suspension unit intact, lift the phase conductor and existing suspension unit and hang it from the middle horizontal post insulator with an anchor shackle; seventh, detach the remaining phase conductor and suspension unit and secure them to the side of the pole

below the crossarm; eighth, remove the bottom crossarm and braces; ninth, install the bottom horizontal post insulator; tenth, lift the bottom phase conductor and existing suspension unit and hang them from the bottom horizontal post insulator with an anchor shackle. (NOTE: An approximate five inches of vertical clearance can be gained by installing the bottom phase conductor with appropriate suspension unit and clamptop clamp to the top of the horizontal post insulator. This would increase the ground clearance for the uprated TS-1-HP Structure to .762m [2'-6"].)

b. <u>TS-1 to TS-15-HP (69 kV to 115 kV or 138 kV)</u>

The basic TS-1 Structure (Figure 89) can be uprated to the TS-15-HP Structure at 115 kV or 138 kV (Figures 100 and 106) if certain criteria are met.

The TS-15-HP Structure provides a bottom conductor location 3.20m (10'-6") from the poletop. This will permit an increase in ground clearance of .53m (1'-9") to be gained by the structure conversion. This increase in ground clearance will be sufficient for voltage uprating to 115 kV or 138 kV only if the original line design was based on a minimum ground clearance of 7.01m (23'-0"). (Old Bulletin 62-1 classification of "Along Rural Roads.")

This structure conversion causes a significant increase in overturning moment. Therefore, the TS-15-HP conversion will probably require the installation of new intermediate span structures in some spans unless the original structures were overdesigned in pole strength.

If the utilization of existing right-of-way is an economic necessity, the number of intermediate span structures is reasonable, and the existing conductor size is adequate for uprated voltage performance, then the TS-15-HP structure may be an economical alternative to a complete line rebuild.

The TS-15-HP provides a shield angle of approximately 36° at 115 kV and 39° at 138 kV. The conductor galloping performance is actually better than that of the original TS-1 structure with the same wire size.

The physical conversion of the structure may be achieved by: first, detaching the existing shield wire (leaving the suspension unit intact), temporarily securing the shield wire to the side of the pole or lowering it to rest on the upper crossarm; second, installing the shield wire bayonet and horizontal post insulator (the bottom bolt for the insulator

passes through the bottom bolt hole of the bayonet); third, lifting the shield wire and existing suspension unit and securing it to the bayonet top with a Y-clevis eye unit, then lifting the top phase conductor and existing suspension unit and hanging it from the insulator with an anchor shackle (NOTE: In 138 kV uprating, the phase conductor should be installed with appropriate suspension unit and clamptop clamp to the top of the horizontal post insulator); fourth, removing the upper crossarm; fifth, drilling mounting holes and installing the new crossarm and braces; sixth, detaching the lower phase conductors and insulator strings; seventh, inserting additional suspension insulators as required in the existing strings and raising the conductors and insulators to their suspension points on the new crossarm; eighth, removing the original lower crossarm.

c. <u>TS-1 to TH-1AM (69 kV to 115 kV or 138 kV)</u>

The basic TS-1 Structure (Figure 89) can be uprated to the TH-1AM Structure (Figure 104 or 108) to operate at 115 kV or 138 kV, if conditions warrant it.

Conversion from the TS-1 to the TH-1AM structure will be significantly more expensive than uprating with the TS-15-HP structure. However, the TH-1AM structure has the distinct advantage that the transmission line can be reconductored with a larger wire.

The TH-1AM structure uprating should be an economical alternative if the original ruling span is 137m (450') or greater, a larger conductor is required, there are no right-of-way encroachments or obstacles, and there are few line angles. The converting and uprating from single pole construction to H-frame construction will require additional right-of-way width. The acquisition of right-of-way is becoming so difficult that it becomes the primary problem to be resolved in any line routing or conversion.

At 115 kV, the TH-1AM structure provides a conductor attachment point 1.65m (5'-5") below the poletop of the original pole. At 138 kV, the conductor attachment point is 1.80m (5'-11") below the poletop. This can provide an increase in ground clearance of 2.08m (6.83') at 115 kV or 1.93m (6.33') at 138 kV.

The TH-1AM uprated structure provides a shield angle of approximately 29° at 115 kV and 28° at 138 kV. The galloping performance (single loop) of the uprated structure is better than the performance of the original structure with the same wire size.

Assuming that reconductoring will be required, the physical conversion of the structure may be achieved by: first, removing the existing conductors; second, installing the additional wood pole; third, detaching the existing shield wire from the poletop (leaving the suspension unit intact), and moving the shield wire to rest temporarily on the outside of the existing top crossarm; fourth, installing the steel bayonet, and steel tie angle; fifth, lifting the existing shield wire and securing it to the steel tie angle with an anchor shackle; sixth, installing the new 7.93m (26') H-frame crossarm; seventh, detaching the existing insulator strings from the existing TS-1 crossarm, inserting additional insulators as required, and securing the insulator strings to the H-frame crossarm; eighth, removing the TS-1 crossarms; ninth, stringing the new shield wire; tenth, stringing the new conductors.

d. TS-1 to TH-10M (69 kV to 161 kV)

The basic TS-1 structure (Figure 89) can be uprated to the TH-10M structure (Figure 110) and operated at 161 kV if certain criteria are met.

The TH-10M structure provides a bottom conductor location 2.11m (6'-11") from the existing poletop compared with 3.73m (12'-3") for the TS-1 structure. This difference in conductor elevation allows an increase in ground clearance of 1.63m (5'-4") to be gained by the structure conversion.

The TH-10M structure uprating should be an economical alternative if the original ruling span is 137m (450') or greater, a larger conductor is required, there are no right-of-way encroachments or obstacles, and there are few line angles. The converting and uprating from single-pole to H-frame construction will require additional right-of-way width. The 161 kV TH-10M installation will require about twice as much right-of-way as the 69 kV TS-1 installation. Uprating to 161 kV on the existing line route should not be considered unless the ability to obtain additional adjacent right-of-way is a certainty.

The TH-10M uprated structure provides a shield angle of approximately 31° to the outside phases. The conductor galloping performance (single loop) of the uprated structure is actually better than that of the original structure with the same wire size.

The sequence of activities for physically converting the structure is the same as for the TH-1AM uprating. The

TH-10M structure utilizes a larger and assembled crossarm, longer steel tie angle, and more suspension insulators.

2. Uprating the TS1X

a. TS-1X to TS-1X-HP (69 kV to 115 kV or 138 kV)

The basic TS-1X structure (Figure 89) can be uprated to the TS-1X-HP structure at 115 kV or 138 kV (Figures 112 and 118) if certain criteria are met.

The TS-1X-HP structure provides a bottom conductor attachment location 3.71m (12'-2") from the pole top. Compared with the bottom conductor location on the TS-1X structure of 4.34m (14'-3"), there is an increase in ground clearance of 0.635m (2'-1"). This increase in ground clearance will be sufficient for voltage uprating to 115 kV or 138 kV only if the original line design was based on a minimum vertical clearance of 7.01m (23'-0") (Old Bulletin 62-1 classification of "Along Rural Roads").

The TS-1X-HP structure provides the top phase wire with a protective shield angle of approximately 36° at 115 kV and 39° at 138 kV. The single loop conductor galloping pattern of the uprated structure is less likely to experience conductor contact than the original TS-1X structure with the same wire size.

The physical conversion of the structure may be achieved by: first, detaching the existing shield wire from the pole top and lowering it to rest on the upper crossarm or temporarily securing it to the side of the pole (leaving the suspension unit intact); second, installing the shield wire bayonet and top horizontal post insulator (the bottom bolt for the insulator passes through the bottom hole of the bayonet; third, lifting the shield wire and existing suspension unit and securing it to the bayonet top with a Y-clevis eye attachment, the lifting the top phase conductor and existing suspension unit and hanging it from the top insulator with one anchor shackle; fourth, removing the upper crossarm and brace; fifth, installing the middle horizontal post insulator; sixth, detaching the lower phase conductor (on the side with the middle horizontal post insulator installed) leaving the suspension unit intact, then lifting the phase conductor and suspension unit and hanging it from the middle horizontal post insulator with an anchor shackle; seventh, detaching the remaining phase conductor and suspension unit and securing them to the side of the pole below the bottom crossarm; eighth, removing the bottom crossarm

and braces; ninth, installing the bottom horizontal post insulator; tenth, lifting the bottom phase conductor and suspension unit and hanging them from the bottom horizontal post insulator with an anchor shackle. (NOTE: An approximate five inches of vertical clearance can be gained by installing the bottom phase conductor with appropriate suspension unit and clamptop clamp to the top of the horizontal post insulator. This would increase the ground clearance for the uprated TS-1X-HP structure to .762m [2'-6"].)

b. <u>TS-1X to TS-15X-HP (69 kV to 115 kV or 138 kV)</u>

The basic TS-1X structure (Figure 89) can be uprated to the TS-15X-HP structure at 115 kV or 138 kV (Figures 114 and 120) if certain criteria are met.

The TS-15X-HP structure provides a bottom conductor location 3.33m (10'-11") from the poletop while the standard TS-1X bottom conductor is located 4.34m (14'-3") from the poletop. Thus, an increase in ground clearance of 1.02m (3'-4") can be attained by the structure conversion. This increase in ground clearance will be sufficient for voltage uprating to 115 kV under most conditions, but uprating to 138 kV will be possible only if the original line design was based on a minimum ground clearance of 7.01m (23'-0") (Old Bulletin 62-1 classification of "Along Rural Roads").

The uprated structure will experience a greater overturning moment due to the elevated attachment points of conductors and shield wire. Therefore, the TS-15X-HP line conversion will probably require the installation of intermediate span structures in some spans unless the original structures were overdesigned in pole strength. The use of intermediate span structures will also reduce conductor "blow-out" and thus help to minimize right-of-way requirements. (NOTE: When uprating to 115 kV, it may not be necessary to use the entire 1.02m (3'-4") gain in ground clearance. If the original line design was based on 7.01m (23'-0") ground clearance, only 0.30m (1'-0") of added ground clearance, or 7.32m (24'-0") total, is required by the current 62-1 Bulletin.)

The TS-15X-HP structure is an economical alternative to a complete tear-down and rebuild. If the original line installation has a 266.8 MCM conductor, this uprated structure will be very economical.

The TS-15X-HP structure provides a protective shield angle to the top phase wire of approximately 36° at 115 kV and 39°

at 138 kV. The conductor galloping pattern is less likely to contact than the original TS-1X structure with the same wire size.

The physical conversion of the structure may be achieved by: first, detaching the existing shield wire (leaving the suspension unit intact), and temporarily securing the shield wire to the side of the pole or lowering it to rest on the upper crossarm; second, installing the shield wire bayonet and horizontal post insulator (the bottom bolt for the insulator passes through the bottom bolt hole of the bayonet); third, lifting the shield wire and existing suspension unit and securing it to the bayonet top with a Y-clevis eye unit; fourth, lifting the top phase conductor and existing suspension unit and hanging it from the horizontal post insulator with an anchor shackle (NOTE: In 138 kV uprating, the top phase conductor should be installed with appropriate suspension unit and clamptop clamp to the top of the horizontal post insulator); fifth, removing the upper crossarm and brace; sixth, drilling mounting holes and installing the new crossarm and braces; seventh, detaching the lower phase conductors and insulator strings; eighth, inserting additional suspension insulators as required in the existing strings and raising the conductors and insulators to their new suspension points on the new crossarm; ninth, removing the original lower crossarm and braces.

c. TS-1X to TH-1AAXM (69 kV to 115 kV or 138 kV)

The basic TS-1X structure (Figure 89) can be uprated to the TH-1AAXM structure (Figures 116 and 122) to operate at 115 kV or 138 kV if conditions warrant it.

Conversion from the TS-1X to the TH-1AAXM structure will be significantly more expensive than uprating with the TS-1X-HP or TS-15X-HP. The TH-1AAXM structure, however, will permit a much larger conductor to be installed to satisfy system requirements.

The TH-1AAXM structure uprating should be an economical alternative if the original ruling span is 137m (450') or greater, a large conductor is required, there are no right-of-way encroachments or obstacles, and there are few line angles. The converting and uprating from single-pole construction to H-frame construction will require additional right-of-way width. This structure should not be considered for line uprating unless the ability to acquire additional right-of-way width is a certainty.

At 115 kV, the TH-1AAXM structure provides a conductor attachment point 1.65m (5'-5") below the poletop of the original pole. At 138 kV, the conductor attachment point is 1.80m (5'-11") below the poletop. This can provide an increase in ground clearance of 2.69m (8'-10") at 115 kV or 2.54m (8'-4") at 138 kV.

The TH-1AAXM uprated structure provides a protective shield angle to the outside phases of approximately 28.6° at 115 kV and 27° at 138 kV. The conductor galloping pattern (single loop) of the uprated structure is much less likely to contact than that of the original TS-1X structure with the same wire size.

Assuming that reconductoring will be required, the physical conversion of the structure may be achieved by: first, removing the existing conductors; second, installing the additional wood pole; third, detaching the existing shield wire from the poletop (leaving the suspension unit intact), and moving the shield wire to rest temporarily on the outside of the existing top crossarm; fourth, installing the steel bayonet and steel tie angle; fifth, lifting the shield wire and existing suspension unit and securing it to the steel tie angle with an anchor shackle; sixth, installing the new 7.92m (26') H-frame assembled crossarm; seventh, detaching the existing insulator strings from the TS-1X crossarms, inserting additional suspension insulators as required, and attaching the insulator strings to the H-frame crossarm attachment points; eighth, removing the TS-1X crossarms and braces; ninth, install the X-brace assembly; tenth, string the second shield wire; eleventh, string the new conductors.

d. <u>TS-1X to TH-10M (69 kV to 161 kV)</u>

The basic TS-1X structure (Figure 89) can be uprated to the TH-10M structure (Figure 124) and operated at 161 kV if certain criteria are met.

The TH-10M structure provides a bottom conductor location 2.11m (6'-11") from the existing poletop compared with 4.34m (14'-3") for the TS-1 structure. This difference in conductor elevation allows an increase in ground clearance of 2.24m (7'-4") to be gained by the structure conversion.

The TH-10M structure uprating should be an economical alternative if the original ruling span is 137m (450') or greater, a larger conductor is required, there are no right-of-way encroachments or obstacles, and there are few line

angles. The converting and uprating from single-pole to H-frame construction will require additional right-of-way width. The 161 kV TH-10M installation will require about twice as much right-of-way as the 69 kV TS-1X installation. Uprating to 161 kV on the existing line route should not be considered unless the ability to obtain additional adjacent right-of-way is a certainty.

The TH-10M uprated structure provides a shield angle of approximately 31° to the outside phases. The conductor galloping performance (single loop) of the uprated structure is actually better than that of the original structure with the same wire size.

The sequence of activities for physically converting the structure is the same as the TH-1AAXM uprating. The TH-10M structure utilizes a larger assembled crossarm, longer steel tie angle, and more suspension insulators.

3. Uprating the TSZ-1

a. <u>TSZ-1 to TSZ-1-HP (69 kV to 115 kV or 138 kV)</u>

The TSZ-1 structure (Figure 90) can be uprated to the TSZ-1-HP structure at 115 kV or 138 kV (Figures 126 and 132) if certain criteria are met.

The TSZ-1 can be readily and economically uprated to the TSZ-1-HP structure. The bottom conductor attachment for the TSZ-1-HP is 3.71m (12'-2") from the pole top. Compared with the bottom conductor location on the TSZ-1 structure of 4.8m (15'-9"), an increase in ground clearance of 1.09m (3'-7") can be obtained by the structure uprating. This additional ground clearance will be sufficient for voltage uprating to 115 kV or 138 kV.

There are two major questions that must be resolved before this structure can be used for voltage uprating. One question is whether or not the existing pole strength is sufficient to withstand the increase in overturning moment and still provide the required safety factor. The second question is whether or not the existing conductor is large enough to operate satisfactorily at the higher voltage.

The TSZ-1-HP structure provides the top phase wire with a protective shield angle of approximately 36° at 115 kV and 39° at 138 kV. The single loop conductor galloping pattern of the uprated structure is better than the original TSZ-1 structure with the same wire size.

The physical conversion of the structure may be achieved by: first, detaching the shield wire and each of the phase conductors individually (leaving their suspension units intact), and lowering each of them to convenient locations and temporarily securing them individually to the sides of the pole; second, removing all the existing arms, braces, and suspension material; third, installing the shield wire bayonet and top horizontal post insulator (the bottom bolt for the insulator passes through the bottom hole of the bayonet); fourth, lifting the shield wire and existing suspension unit and securing it to the bayonet top with a Y-clevis eye attachment; fifth, installing the middle and bottom horizontal post insulators at their designated locations; sixth, lifting the middle and bottom phase conductors and their existing suspension units and attaching them to their respective horizontal post insulators with anchor shackles. (NOTE: An approximate 12.7cm (5") of additional ground clearance can be gained by installing the bottom phase conductor with appropriate suspension unit and clamp-top clamp to the top of the horizontal post insulator. This method of attachment is recommended when uprating to 138 kV.)

b. TSZ-1 to TSZ-MPH (69 kV to 115 kV or 138 kV)

The TSZ-1 structure (Figure 90) can be uprated to the TSZ-MPH structure at 115 kV or 138 kV (Figures 128 and 134) if certain criteria are met.

The TSZ-MPH structure provides a bottom conductor location 3.33m (10'-11") from the poletop while the standard TSZ-1 bottom conductor is located 4.8m (15'-9") from the poletop. Thus, an increase in ground clearance of 1.45m (4'-9") can be obtained by the structure conversion. This increase in ground clearance will be sufficient for voltage uprating to 115 kV or 138 kV.

For uprating to 115 kV or 138 kV, the limiting factor in the TSZ-MPH structure will be pole strength. The uprated structure will experience greater overturning moment due to elevated attachment points of conductors and shield wire. Therefore, the TSZ-MPH line conversion will probably require the installation of intermediate span structures in some spans unless the original structures were overdesigned in pole strength. The use of intermediate span structures will also reduce conductor "blow-out" and thus help to minimize additional right-of-way requirements.

The TSZ-1 can be quickly and economically uprated to the TSZ-MPH structure, particularly if the original wire size is large enough to operate satisfactorily at the higher voltage (e.g., 266.8 MCM or 336.4 MCM ACSR). (NOTE: When uprating to 115 kV, it may not be necessary to use the entire 1.45m (4'-9") gain in ground clearance. If the original line design was based on 7.01m (23'-0") ground clearance, only .3048m (1'-0") of added ground clearance, or 7.32m (24'-0") total is required by the current 62-1 Bulletin at 75°C (167°F) or the maximum conductor operating temperature.)

The TSZ-MPH structure provides the top phase wire with a protective shield angle of approximately 36° at 115 kV and 39° at 138 kV. The conductor galloping pattern of the uprated structure is less likely to contact than the original TSZ-1 structure with the same wire size.

The physical conversion of the structure may be achieved by: first, detaching the shield wire and each of the phase conductors individually (leaving their suspension units intact), and lowering each of them to convenient locations and temporarily securing them individually to the sides of the pole; second, removing all the existing arms, braces and suspension material; third, installing the shield wire bayonet and top horizontal post insulator (the bottom bolt for the insulator passes through the bottom hole of the bayonet); fourth, lifting the shield wire and existing suspension unit and securing it to the bayonet top with a Y-clevis eye attachment; fifth, lifting the top phase conductor and existing suspension unit and hanging it from the horizontal post insulator with an anchor shackle; sixth, drilling mounting holes and installing the new crossarm, braces, and strings of suspension insulators; seventh, lifting the two bottom phase conductors and existing suspension units and attaching them to their respective insulator strings.

c. <u>TSZ-1 to TH-1A (MOD) (69 kV to 115 kV or 138 kV)</u>

The standard TSZ-1 structure (Figure 90) can be uprated to the TH-1A (MOD) structure (Figures 130 and 136) to operate at 115 kV or 138 kV if conditions require it.

Line conversion from the TSZ-1 to the TH-1A (MOD) will be more costly than uprating with the single pole structures TSZ-1-HP or TSZ-MPH. The TH-1A (MOD) uprated structure, however, provides significant alternatives that the single-pole structures do not. The TH-1A (MOD) structure will permit a much larger conductor to be installed to satisfy

system operating requirements. It also provides more ground clearance than either of the uprated single-pole structures. (The H-frame strength and conductor height may allow the elimination of some existing single-pole structures.)

The TH-1A (MOD) uprated structure is an economical alternative if reconductoring with a larger conductor is necessary, the existing spans are relatively long (ruling span is 137m [450'] or greater), there are few line angles involved, and there are no right-of-way encroachments or obstacles. The conversion and uprating from single-pole to H-frame construction will require additional right-of-way width. This method of line conversion should not be pursued until the owner is certain of their ability to acquire additional adjacent right-of-way.

At 115 kV, the TH-1A (MOD) structure provides a conductor attachment point 1.68m (5'-6") below the poletop of the original pole. At 138 kV, the conductor attachment point is 1.83m (6'-0") below the poletop. These attachment points will allow an increase in ground clearance of 3.12m (10'-3") at 115 kV or 2.97m (9'-9") at 138 kV.

The TH-1A (MOD) structure provides a protective shield angle of approximately 31° at 115 kV or 29° at 138 kV. The conductor galloping pattern (single loop) of the uprated structure is much better than that of the original structure with the same wire size.

Assuming that reconductoring will be required in the uprating, the physical conversion of the structure may be achieved by: first, removing the existing conductors and insulator strings; second, installing the additional wood pole; third, detaching the existing shield wire from the poletop (leaving the suspension unit intact), moving the shield wire to the outside of the pole (if necessary), and temporarily securing the shield wire to the side of the pole near the top crossarm; fourth, installing the steel bayonet and steel tie angle; fifth, lifting the shield wire and existing suspension unit and securing it to the steel tie angle with an anchor shackle; sixth, removing the TSZ-1 crossarms and braces; seventh, installing the new 7.92m (26') H-frame crossarm; eighth, installing strings of suspension insulators from the H-frame crossarm attachment points; ninth, installing X-brace assembly TM 110 (if necessary); tenth, stringing the second shield wire; eleventh, stringing the new conductors. (NOTE: During the TH-1A [MOD] structure uprating a second pole of 1.52m [5'] additional height is installed. If

and when the existing original pole deteriorates, it can be replaced with a 1.52m [5'] taller pole thus eliminating the bayonet and resulting in greater structure reliability.)

d. <u>TSZ-1 to TH-10K (69 kV to 161 kV)</u>

The standard TSZ-1 structure (Figure 90) can be uprated to the TH-10K structure (Figure 138) and operated at 161 kV if conditions require it.

The TH-10K structure provides a conductor attachment point 2.54m (8'-4") below the existing poletop compared with 4.8m (15'-9") for the standard TSZ-1 structure. This difference in conductor elevation allows an increase in ground clearance of 2.26m (7'-5") to be gained by the structure conversion.

The TH-10K structure uprating should prove to be an alternative if the existing spans are relatively long (ruling span is 137m [450'] or greater), there are few line angles involved, and there are no right-of-way encroachments or obstacles. The uprating from single-pole 69 kV construction and operation to H-frame 161 kV construction and operation will require about twice as much right-of-way as the original line required. (NOTE: Additional right-of-way will probably be required on both sides of the existing centerline. More right-of-way will be required on the side which has the new pole installed, since the new centerline is moved 2.36m (7'-9") in that direction. Additional clearance will also be required to allow for conductor blowout, clearance to edge or right-of-way at 161 kV, etc.). Uprating to 161 kV along the existing line route should not be pursued until the owner is certain of their ability to acquire additional adjacent right-of-way.

The TH-10K uprated structure provides a protective shield angle of approximately 30° to the outside phase conductors. The conductor galloping pattern (single loop) of the uprated structure is much better than that of the original structure with the same wire size.

The structural considerations and sequence of activities involved in physically uprating the TH-10K structure are very similar to the TH-1A (MOD) conversion. The TH-10K structure utilizes a longer crossarm, longer steel tie angle and more suspension insulators.

H-FRAME STRUCTURE MODIFICATIONS

1. Uprating the TH-1G.

   a. TH-1G to TH-VS (69 kV to 115 kV or 138 kV)

The standard TH-1G structure (Figure 91) can be uprated to the TH-VS structure (Figures 140 and 146) to operate at 115 kV or 138 kV if certain criteria are met.

Line conversion from the TH-1G to the TH-VS to operate at 115 kV or 138 kV can be accomplished at reasonable cost if the existing conductor size is large enough to operate at the higher voltage (see Table II-1). If the existing wire size is not adequate for uprated voltage operation, it is doubtful that the pole strength of an uprated TH-VS structure will be adequate to permit reconductoring.

The conductor attachment point of the TH-VS is 1.63m (5'-4") below the pole top at 115 kV or 1.78m (5'-10") below the poletop at 138 kV. The uprated structure thus provides an increase in ground clearance of 1.22m (4'-0") at 115 kV or 1.07m (3'-6") at 138 kV. This should allow sufficient vertical clearance to permit structure uprating to 115 kV, but uprating to 138 kV is feasible only if the original line design was based on vertical clearance "Along Rural Roads" (see Table IV-2).

The TH-VS structure provides a protective shield angle of approximately 32° at 115 kV or 31° at 138 kV. The conductor galloping pattern (single loop) is better than that of the original structure with the same wire size (i.e., less probability of conductor contact).

The physical conversion of the structure may be achieved by: first, detaching the existing shield wires (leaving the suspension units intact), and lowering them to rest upon the top of the existing crossarm; second, removing the existing shield wire cable support assemblies; third, installing the two steel bayonets and Overhead Ground Wire Support Assembly (TM-109); fourth, lifting the shield wires and securing the existing suspension units to the OHGW Support Assembly with anchor shackles; fifth, detaching the existing conductors (leaving the suspension units intact), lowering them to a convenient location and temporarily securing them to the sides of the poles; sixth, removing the existing crossarm; seventh, installing the new crossarm; eighth, installing the suspension insulator units; ninth, detaching the conductors from their temporary points of security, lifting them and

securing the existing suspension units to the insulator strings, (NOTE: for conductor sizes less than 266.8 MCM 26/7, the center phase may require an alternate suspension unit consisting of two socket Y-clevis units, a Vee string yoke plate, and anchor shackle); tenth, installing the X-brace assembly, or relocating the existing X-brace assembly, as required.

Structures with spans of 152m (500 feet) or more may be strengthened at the top by using four steel bayonets; a bayonet could be installed on the outside of the poletop as well as the inside and both bayonets secured to the steel tie bar between the two poles.

b. TH-1G to TH-HPX (69 kV to 115 kV or 138 kV)

The standard TH-1G structure (Figure 91) can be uprated to the TH-HPX structure (Figures 142 and 148) to operate at line voltages of 115 kV or 138 kV.

The TH-HPX structure can be converted at comparatively low cost but provides one of the more reliable structures when uprating from 69 kV with existing 4/0 AWG or 266.8 ACSR conductor. This structure was used in 1975 to convert a line in Oklahoma from 69 kV to 138 kV. The line is still in service with no unusual operating problems.

The TH-HPX structure provides a conductor shield angle of approximately 27° at 115 kV and 30° at 138 kV. A better conductor galloping pattern (single loop) is provided by the uprated structure than the standard TH-1G structure with the same wire size. Another positive feature of the TH-HPX is the fact that insulator swing is eliminated and the need for added right-of-way width is minimized.

An additional 1.63m (5'-4") of ground clearance can be attained by the TH-HPX uprating to 115 kV or 138 kV.

The physical conversion of the TH-HPX structure may be achieved by: first, detaching the existing shield wires (leaving the existing suspension units intact), and lowering them to rest upon the existing crossarm; second, removing the existing shield wire cable support assemblies; third, installing the two steel corner bayonets and the middle phase Vee string insulators and hardware items; fourth, lifting the shield wires and hanging the existing suspension units from the bayonet tops with anchor shackles; fifth, detaching the existing conductor (leaving the suspension units intact), lowering them to a convenient location and securing them,

temporarily, to the sides of the poles; sixth, removing the existing crossarm assemblies and insulator strings; seventh, installing the two horizontal line post insulators; eighth, detaching the two outside phase conductors, lifting them and securing their existing suspension units from the line post insulators with anchor shackles; ninth, detaching the middle phase conductor, lifting it, and securing its existing suspension unit to the Vee string attachment (NOTE: For conductor sizes less than 266.8 MCM 26/7, the center phase may require an alternate suspension attachment consisting of two socket Y-clevis units, a Vee string yoke plate, and anchor shackle); tenth, installing the X-brace assembly, or relocating the existing X-brace assembly, as required.

c. <u>TH-1G to TH-24A (69 kV to 115 kV or 138 kV)</u>

The standard TH-1G structure (Figure 91) can be uprated to the TH-24A structure (Figures 144 and 150) and operated at 115 kV or 138 kV, if certain criteria are met.

This conversion structure can be developed with either steel corner bayonets or straight bayonets and no steel tie bar. The TH-24A structure is an economical conversion alternative if the existing conductor is suitable for operation at the higher voltage. If reconductoring is necessary, it is doubtful that the TH-24A would have adequate pole strength.

The TH-24A structure provides a conductor attachment point 1.75m (5'-9") below the pole top at 115 kV or 138 kV. This will result in a gain in ground clearance of 1.09m (3'-7") at either 115 kV or 138 kV. Table IV-2 indicates that a gain of 1.07m (3.5') in vertical clearance should be adequate to uprate from 69 kV to 115 kV, but uprating to 138 kV would be feasible only if the original line design was based on vertical clearance "Along Rural Roads."

A conductor shield angle of approximately 29° is provided by the uprated structure. The conductor galloping pattern (single loop) is better than the original structure with the same wire size (i.e., less likely to experience conductor contact).

The physical conversion of the TH-24A structure may be achieved by: first, detaching the existing shield wires (leaving the suspension units intact), and lowering them to rest upon the top of the existing crossarm; second, removing the existing shield wire support assembly units; third, installing the two steel bayonets (either straight or corner bayonets, as required); fourth, lifting the shield wires and

securing the existing suspension units to the bayonet tops with anchor shackles; fifth, detaching the existing conductor (leaving the suspension units intact), lowering them to the sides of the poles; sixth, removing the existing crossarm and insulator strings; seventh, installing the new crossarm; eighth, installing the new suspension insulator units; ninth, detaching the conductors from their temporary locations, lifting them to their respective attachment points, and securing them to the insulator strings (NOTE: For conductor sizes less than 266.8 MCM 26/7 ACSR, the center phase may require an alternate suspension unit consisting of two socket Y-clevis units, a Vee string yoke plate, and anchor shackle); tenth, installing the X-brace assembly, or relocating the existing X-brace assembly, as required.

d. <u>TH-1G to TH-161MT (69 kV to 161 kV)</u>

The standard TH-1G structure (Figure 91) can be uprated to the TH-161MT structure (Figure 152) and operated at 161 kV.

The cost involved in uprating a line to the TH-161MT structure at 161 kV will approach the cost of rebuilding the line. This is due, in part, to the fact that high strength horizontal post insulators must be used and that one wood pole must be replaced with a 15-foot taller pole, which is one class larger than the original (a 50'-3 must be replaced with a 65'-2). This uprating structure should not be considered unless the existing conductor is 397.5 MCM or larger.

One advantage in using the TH-161MT structure is the fact that the existing right-of-way can be utilized with minimal additional width requirements. The horizontal post insulators eliminate insulator swing problems. The conductor attachment points on the uprated structure provide an increase in ground clearance of 1.02m (3'-4"). Another advantage is the elimination of one shield wire and the structural loading effect it imposes.

The TH-161MT structure provides a protective shield angle of approximately 40°. The conductor galloping pattern (single loop) is better than the original structure with the same wire size (less likely to experience conductor contact).

The physical conversion of the TH-161MT structure may be achieved by: first, framing the 15' taller replacement pole on the ground, installing the ground wire cable support unit and two high strength horizontal line post insulators at their respective locations; second, detaching the shield wire from

the pole that is to be removed, removing its suspension unit, and removing and retiring that shield wire from the line; third, disconnecting the X-brace assembly (if one exists) from the pole that is to be removed; fourth, detaching the existing conductors (leaving suspension units intact) from their existing suspension points; fifth, using appropriate hot stick tools, wire tongs, or slings and temporarily securing the outside and middle phases to the pole that will remain, at a convenient location near their original elevation; sixth, installing a sling around the remaining phase, using a boom to lift, pull, and hold the conductor away from the pole; seventh, removing the existing crossarm and suspension insulators; eighth, removing the wood pole; ninth, enlarging and cleaning the hole left by the removed pole; tenth, installing the new pole with insulators mounted; eleventh, relieving boom tension, positioning the restrained conductor at the bottom horizontal post insulator, and securing the conductor to the insulator; twelfth, attaching the existing X-brace to the new pole; thirteenth, releasing the middle phase, raising it to the top insulator on the new pole and securing the conductor to the insulator; fourteenth, backfilling and tamping the new pole hole; fifteenth, installing the overhead guy unit (TG-15) between the two poles; sixteenth, detaching the remaining shield wire from the shorter pole (leaving the suspension unit intact), raising the shield wire to the top of the taller pole and attaching it to the new suspension point; seventeenth, releasing the remaining conductor from its temporary restraints, raising it and securing the existing suspension unit to the horizontal post insulator.

2. Uprating the TH-1A.

a. <u>TH-1A to TH-VS (115 kV to 161 kV)</u>

The basic TH-1A structure (Figure 92) can be uprated to the TH-VS structure (Figure 154) to operate at 161 kV if certain criteria are met.

In order to uprate from 115 kV to 161 kV, the existing conductor must be 397.5 MCM ACSR or larger (see Table II-1). If reconductoring is necessary for 161 kV operation, it is doubtful that the TH-VS structure would be economical. If, however, the existing wire size is adequate, the uprating procedure is relatively easy. Additional right-of-way width will probably be required on both sides of the centerline.

The TH-VS structure has a conductor attachment point 2.36m (7'-9") below the poletop. Therefore, an increase in ground

clearance of .91m (3'-0") can be gained by the structure uprating.

The TH-VS structure provides a protective shield angle of approximately 34° at 161 kV. The conductor galloping pattern (single loop) is less likely to experience conductor contact than the original structure would with the same wire size installed.

The physical conversion of the structure may be achieved by: first, detaching the existing shield wires (leaving the suspension units intact), and lowering them to rest temporarily upon the top of the existing crossarm; second, removing the existing ground wire support units, and two pole tie assembly; third, installing the two steel bayonets and overhead ground wire support assembly (TM-109); fourth, lifting the shield wires and hanging their existing suspension units from the TM-109 tie bar with anchor shackles; fifth, detaching the existing conductors (leaving the suspension units intact), lowering them to a convenient location and temporarily securing them to the sides of the poles; sixth, removing the existing crossarm and insulators; seventh, installing the new 9.14m (30') assembled crossarm; eighth, installing the suspension insulator units; ninth, detaching the conductors from their temporary locations, raising them to their respective suspension points and securing the existing suspension units to the insulator strings; tenth, installing the X-brace assembly or relocating it, as required.

b. <u>TH-1A to TH-HFS (115 kV to 161 kV)</u>

The basic TH-1A structure (Figure 92) can be uprated to the TH-HFS structure (Figure 156) to operate at 161 kV if certain criteria are met and system requirements warrant it.

As noted in Table II-1, the minimum recommended wire size for 161 kV operation is 397.5 MCM ACSR. If the existing conductor size satisfies this requirement, the line uprating can be made at a reasonable cost. If it is necessary to reconductor the line for 161 kV operation, it would be economical to do so only if the original structure was a TH-1A with no X-braces.

The TH-HFS structure requires three strut insulator assembly units to control insulator swing and maintain electrical clearance to the structure. The strut units also convey a significant portion of the transverse load to a point on the structure parallel with the conductor attachment. That point of application is actually below the location of the original crossarm, thus slightly reducing the moment lever arm.

The TH-HFS structure has a conductor attachment point 2.08m (6'-10") below the poletop. This permits an increase in ground clearance of 1.19m (3'-11") to be gained by the structure conversion.

A shield angle of approximately 29° protects the conductor. The conductor galloping pattern (single loop) is much better than that of the original structure with the same wire size.

The physical conversion of the TH-HFS structure can be achieved by: first, detaching the existing shield wires (leaving the suspension units intact), and lowering them to rest temporarily upon the top of the crossarm; second, removing the existing ground wire support units and two pole tie assembly; third, installing the two steel bayonet units; fourth, lifting the shield wires and hanging their existing suspension units from the bayonet tops by anchor shackles; fifth, detaching the existing conductors (leaving the suspension units intact), lowering them to a convenient location and temporarily securing them to the sides of the poles; sixth, detaching the existing crossarm and insulators, raising the entire unit to its new location and reinstalling it; seventh, adding suspension insulators as required; eighth, installing strut insulator assemblies at their specified locations; ninth, detaching the conductors from their temporary locations, raising them to their respective attachment points, and securing them to the combination strut-suspension insulator unit; tenth, installing X-brace units, or relocating them, as required.

c. <u>TH-1A to TH-161MV (115 kV to 161 kV)</u>

The standard TH-1A structure (Figure 92) can be uprated to the TH-161MV structure (Figure 158) to operate at 161 kV if certain criteria are met.

The minimum recommended conductor size for 161 kV is 397.5 MCM ACSR (see Table II-1). Therefore, if the existing conductor is sufficiently large for 161 kV operation and the original line design was based on vertical clearance "Along Rural Roads" (see Table IV-2), then the TH-161MV structure uprating would be feasible. This structure will not lend itself to reconductoring due to the small amount of vertical clearance gained in uprating. (The conductor attachment point is 2.67m [8'-9"] below the poletop. This results in a gain in vertical clearance of only .61m [2'-0"].)

The TH-161MV structure has certain advantages for 115 kV to 161 kV conversion. One of the advantages is that the

use of Vee string insulators on the outside phases eliminates insulator swing, reduces conductor blow-out, and effectively gains .91m (three feet) of right-of-way width (outside conductor attachments are each .46m (1.5 feet) closer to the centerline than on the original TH-1A structure). Another advantage is that the existing shield wire configuation is used.

A protective shield angle of approximately 25° is provided by the revised structure. The conductor galloping pattern (single loop) is as good as the original TH-1A structure with the same wire size.

The physical conversion of the TH-161MV structure may be achieved by: first, detaching the existing conductors (leaving the suspension units intact), lowering them to a convenient location, and temporarily securing them to the sides of the poles; second, installing the new 9.75m (32') assembled crossarm; third, installing the pole eye plates and appropriate Vee string assembly units; fourth, detaching the conductors from their temporary locations, raising them to their respective suspension points and suspending them from the Vee string yoke plate with an appropriate connecting piece; fifth, installing or relocating the X-brace assembly, as required.

3. Uprating the TH-10.

   a. <u>TH-10 to TH-HFST (161 kV to 230 kV)</u>

The standard TH-10 structure (Figure 93) can be uprated to the TH-HFST structure (Figure 160) to operate at 230 kV if certain conditions are met.

The TH-HFST structure provides a conductor attachment location 2.54m (8'-4") below the poletop, while the standard TH-10 conductor is located 4.17m (13'-8") from the poletop. Thus, an increase in vertical clearance of 1.63m (5'-4") can be attained by the structure conversion.

As noted in Table II-1, the minimum recommended conductor size for 230 kV is 795 MCM ACSR. It is probable that the line will have to be reconductored as well as uprated. A possible alternative might be the utilization of bundled conductor for 230 kV operation. In either case, the pole strength at the groundline will be the determining factor as to whether or not the original structure can be uprated.

The TH-HFST structure utilizes the existing 9.75m (32') assembled crossarm with certain modifications. Adjustable spacers are added to the crossarms and two strut insulators are used to restrain and insulate the outside phases. Little, if any, additional right-of-way width is required in this particular case of uprating.

An approximate shield angle of 30° is realized by the revised structure. The conductors are all restrained; therefore, the conductor galloping pattern (single loop) is much better than that of the original structure with the same wire size installed.

Assuming that the existing wire size is adequate to allow structure uprating, the physical conversion of the TH-HFST structure can be achieved by: first, detaching the existing shield wires (leaving the suspension units intact), and lowering them to rest temporarily upon the top of the existing crossarm; second, removing the existing ground wire support units and OHGW support assembly (TM-109); third, installing the steel bayonet units and installing the OHGW support assembly (TM-109) at the top of the bayonets; fourth, lifting the shield wires and hanging their existing suspension units from the tie bar; fifth, detaching the existing conductors (leaving the suspension units intact), lowering them to a convenient location, and temporarily securing them to the sides of the poles; sixth, detaching the existing crossarm and insulators, raising the entire unit to its new location and reinstalling it; seventh, revising the center phase suspension hardware on the crossarm; eighth, adding suspension insulators to the outside phases, and Vee string assembly for the center phase; ninth, installing strut insulator assemblies for the outside phases; tenth, detaching the conductors from their temporary locations, raising them to their respective attachment points, and securing them; eleventh, installing or relocating X-brace units as required.

b. TH-10 to TH-230MV (161 kV to 230 kV)

The standard TH-10 structure (Figure 93) can be uprated to the TH-230MV structure (Figure 162) to operate at 230 kV if certain criteria are met.

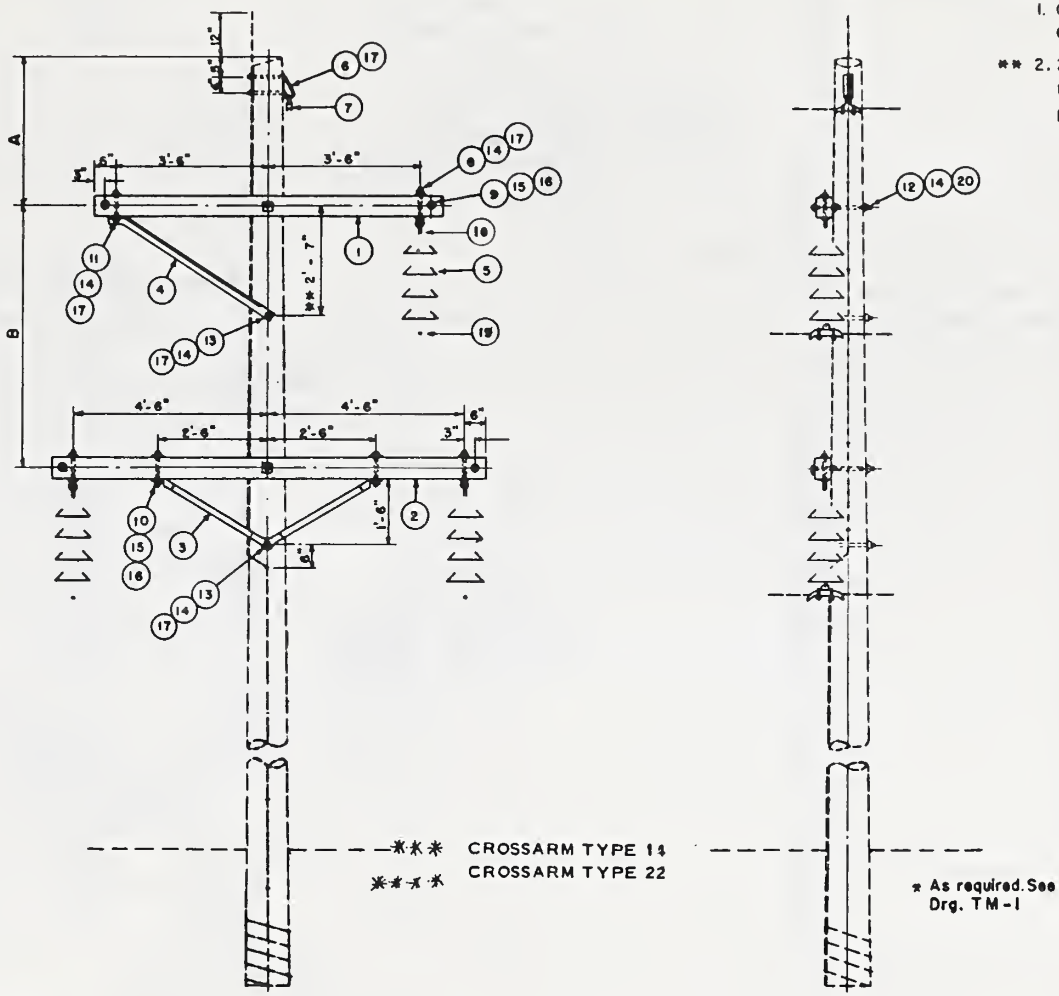
The minimum recommended conductor size for 230 kV is 795 MCM ACSR (see Table II-1). Therefore, if the existing conductor is sufficiently large for 230 kV operation and the original line design was based on vertical clearance "Along Rural Roads" (see Table IV-2), then the TH-230MV structure uprating would be feasible. This structure will not lend

itself to reconductoring due to the small amount of vertical clearance gained in uprating. (The conductor attachment point is 3.56m [11'-8"] below the poletop. This results in a gain in vertical clearance of only .61m [2'-0"].)

The TH-230MV structure has certain advantages for 161 kV to 230 kV conversion. One of the advantages is that the use of Vee string insulators on the outside phases eliminates insulator swing, reduces conductor blowout, and effectively gains .91m (three feet) of right-of-way width (outside conductor attachments are each .46m [1.5 feet] closer to the centerline than on the original TH-10 structure). Another advantage is that the existing shield wire configuration is used.

A protective shield angle of approximately 26° is provided by the revised structure. The conductor galloping pattern (single loop) is better than the original TH-10 structure with the same wire size.

The physical conversion of the TH-230MV structure may be achieved by: first, detaching the existing conductors (leaving the suspension units intact), lowering them to a convenient location, and temporarily securing them to the sides of the poles; second, installing the new 12.2m (40') assembled crossarm; third, installing the pole eye plates, and appropriate Vee string assembly units; fourth, detaching the conductors from their temporary locations, raising them to their respective suspension points and suspending them from the Vee string yoke plate with an appropriate connecting piece; fifth, installing or relocating the X-brace assembly, as required.



NOTES:

1. On Straight Lines Items 6 and 7 May be Mounted On Opposite Of The Pole.

** 2. 2'-7" Dimension is Approximate. Proper Assembly Should Raise Unloaded Conductor Position 1 1/2 Inches Above Level Position By Tilting Crossarm.

DRG. NO.	DIMENSIONS A	DIMENSIONS B
TS-1	3'-6"	6'-0"
TS-1X	4'-6"	7'-0"

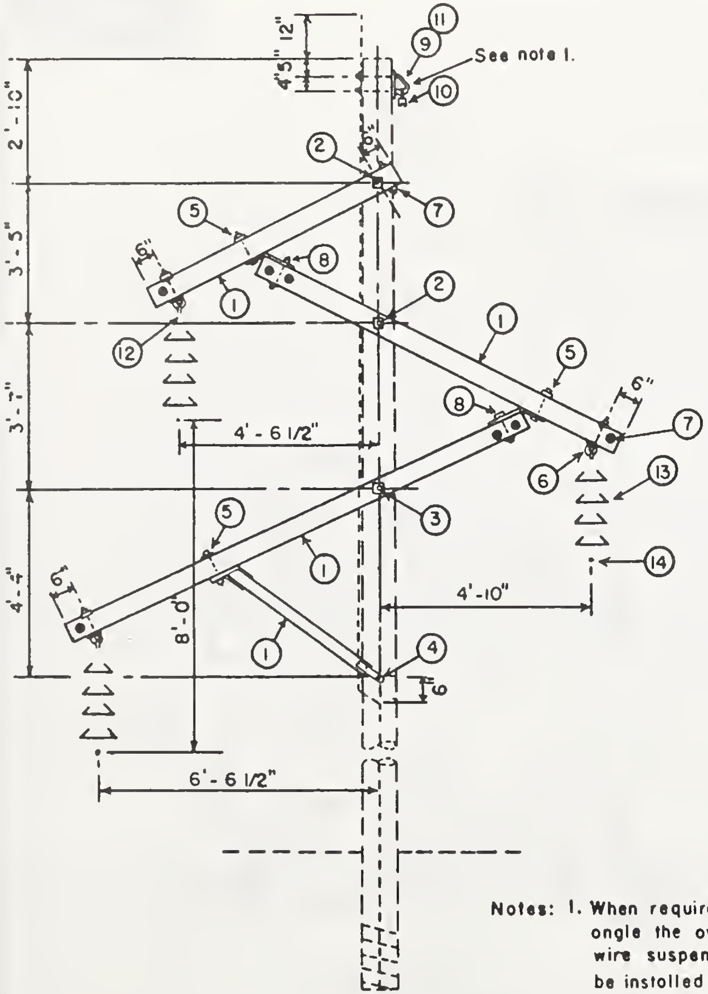
LIST OF MATERIAL

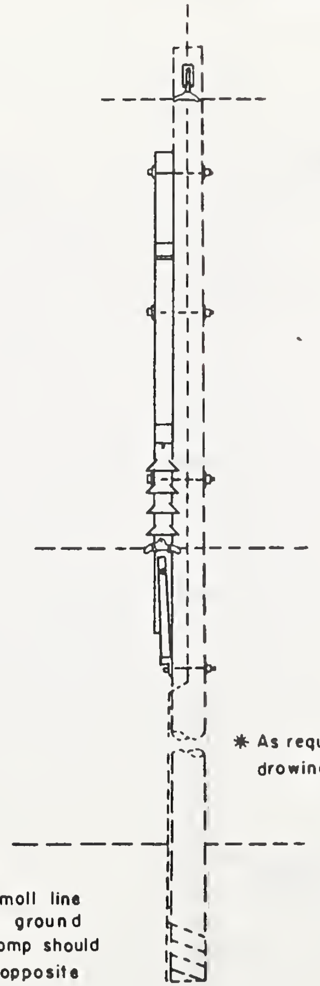
DRG. REF.	REQ'D	DESCRIPTION	ITEM
1	1	4 5/8" x 5 5/8" Wood Crossarm ***	g
2	1	4 5/8" x 5 5/8" Wood Crossarm ****	g
3	1	60" Wood Crossarm Brace	cu
4	1	48" Alloy Arm Brace	em
5	*	5 3/4"x10" Suspension Insulator	k
6	1	Ground Wire Cable Support	ed
7	1	Ground Wire Suspension Clamp	m
8	3	5/8"x8" Eye Bolt	o
9	4	1/2"x7" Machine Bolt	c
10	2	1/2"x8" Machine Bolt	c
11	1	5/8"x8" Machine Bolt	c
12	2	3/4"x18" Machine Bolt	c
13	2	5/8" Machine Bolt, Length as Required	c
14	13	2 1/4"x 2 1/4"x 3/16" Galv. Sq Washer, 13/16" Hole	d
15	10	1 3/8" Galv. Round Washer, 9/16" Hole	d
16	6	Locknuts for 1/2" Bolt	ek
17	8	Locknuts for 5/8" Bolt	ek
18	3	Suspension Hook	eh
19	3	Suspension Clamp and Connecting Piece	el
20	2	Locknuts for 3/4" Bolts	ek

TRANSMISSION LINE TANGENT STRUCTURE
____ KV. SINGLE POLE SUSPENSION
(69 KV. MAXIMUM)

1	REVISED	7-72	
Scale: N.T.S.		Date. Feb., 1967	TS-1,TS-1X

Figure 89





* As required. See drawing TM-1.

Notes: 1. When required by small line angle the overhead ground wire suspension clamp should be installed on the opposite side of the pole.

2. For other requirements refer to specification T-5.

		REVISED	7-72

LIST OF MATERIALS

DRG. REF.	REQ'D	DESCRIPTION	ITEM
1	1	3 5/8" 5 5/8": Wood Crossarm assembly complete with brace and attaching hardware, fittings and bolts. Bolt lengths and sizes as follows:	gz-1
2	2	3/4" x 16" bolt	
3	1	3/4" x 18" bolt	
4	1	5/8" x 14" bolt	
5	3	5/8" x 7 1/2" bolt	
6	3	5/8" Eye bolt and Saddle	
7	4	1/2" bolt x required length	
8	6	1/2" bolt x required length	
		See Note 2	
9	1	Ground Wire Cable Support	ed
10	1	Ground Wire Suspension Clamp	m
11	2	Locknut for 5/8" bolt	ek
12	3	Suspension Hook	eh
13	*	5 3/4" x 10" Suspension Insulator	k
14	3	Suspension Clamp and Connecting Piece	ei

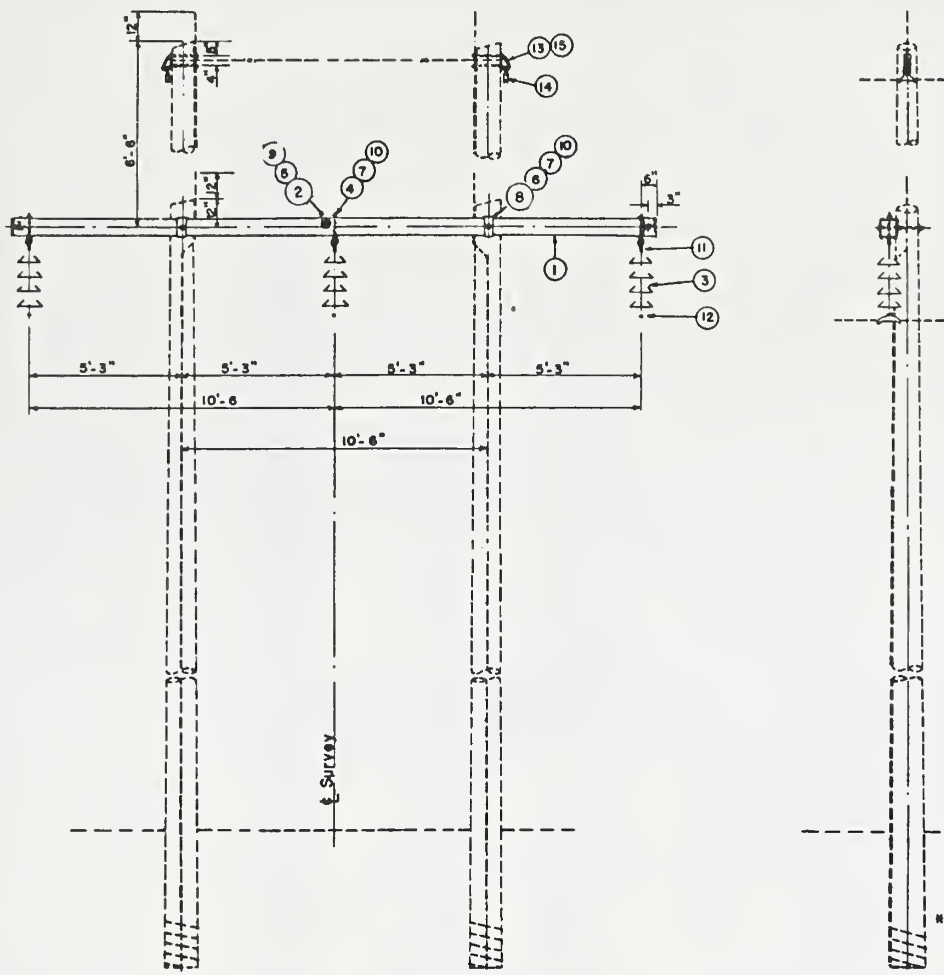
TRANSMISSION LINE TANGENT STRUCTURE
SINGLE POLE SUSPENSION - SINGLE ARM
(69 KV. MAXIMUM)

Scale

Date: Jan 12 '61

TSZ - 1

Figure 90



*As required. See Drg. TM-1

✱✱ CROSSARM TYPE 4"

Designation without Overhead Ground is TH-1.
Designation with Overhead Ground is TH-1G.

LIST OF MATERIAL

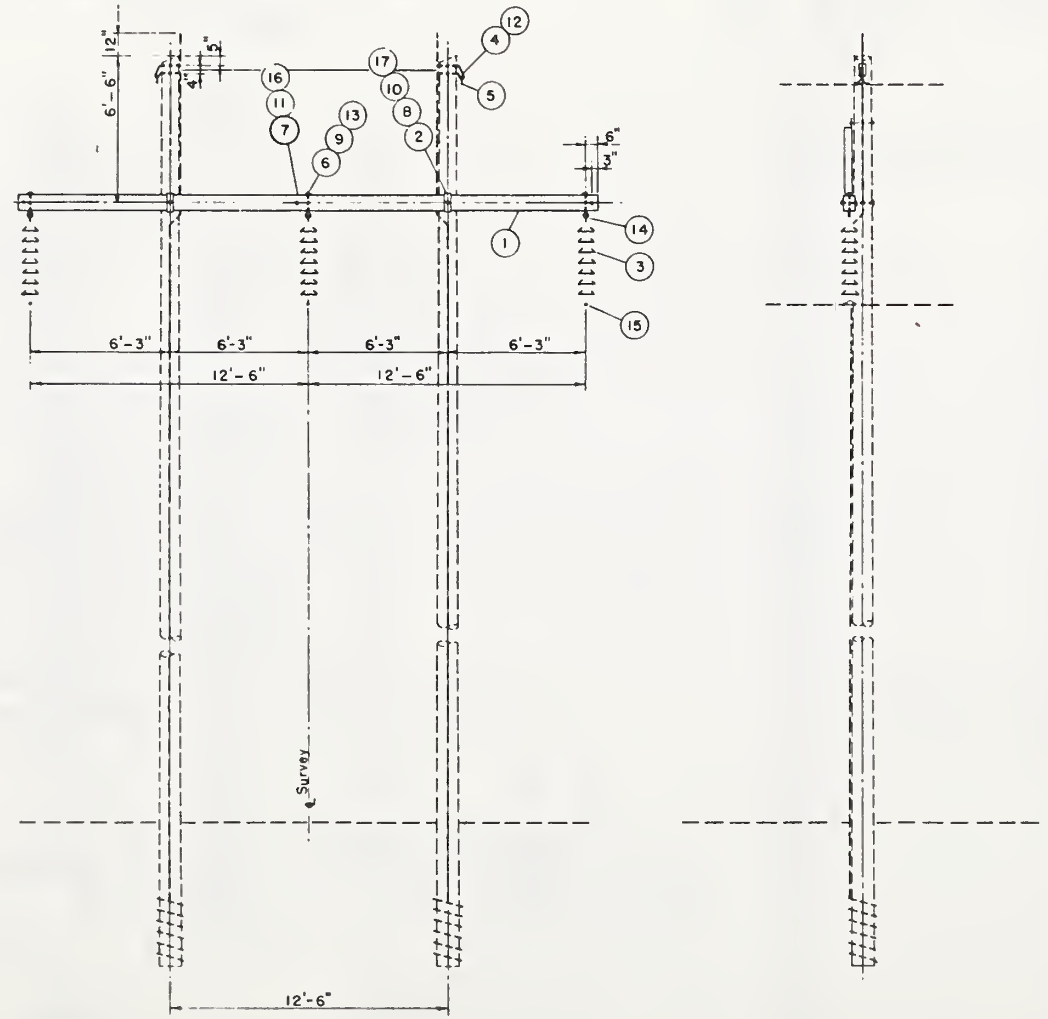
DR'G REF.	REQ'D	DESCRIPTION	ITEM
1	1	5 5/8" x 7 3/8" Crossarm ✱✱	g
2	6	2 1/4"x 2 1/4"x 3/16" Galv. Sq. Washer, 13/16" Hole	d
3	*	5 3/4"x 10" Suspension Insulator	k
4	3	3/4"x 10" Eye Bolt	o
5	3	1/2"x 8" Machine Bolt	c
6	2	3/4"x 18" Machine Bolt	c
7	8	4"x 4"x 3/16" Galv. Sq. Washer, 13/16" Hole	d
8	2	REINFORCING PLATE FOR 8" CROSSARM	eg
9	3	Locknuts for 1/2" Bolt	ek
10	5	Locknuts for 3/4" Bolt	ek
11	3	Suspension Hook	eh
12	3	Suspension Clamp and Connecting Piece	el
		ADDITIONAL MATERIAL FOR TH-1G	
13	2	Ground Wire Cable Support	ed
14	2	Ground Wire Suspension Clamp	m
15	4	Locknuts for 5/8" Bolt	ek

No.	REVISION	Date:
2	REVISED	7-72
1	Reissued	8-56

TRANSMISSION LINE TANGENT STRUCTURE
____KV. H-FRAME SUSPENSION - TWO POLE
(34.5 TO 69 KV.)

Scale:		Date: 11-49
		TH-1, TH-1G

Figure 91



LIST OF MATERIAL			
DRG. REF.	REQ'D	DESCRIPTION	ITEM
1	1	5 3/8"x 7 5/8"x 26'-0" Wood Crossarm, Type 55	g
2	2	Reinforcing Plate for 8" Crossarm	eg
3	*	5 3/4"x10" Suspension Insulator	k
4	2	Ground Wire Cable Support	ed
5	2	Ground Wire Suspension Clamp	m
6	3	3/4"x10" Eye Bolt	o
7	3	1/2"x8" Machine Bolt	c
8	2	7/8"x reqd length, Machine Bolt	c
9	10	4"x4"x 3/16" Galv. Sq. Washer, 13/16" Hole	d
10	2	Locknuts for 7/8" Bolt	ek
11	3	Locknuts for 1/2" Bolt	ek
12	4	Locknuts for 5/8" Bolt	ek
13	5	Locknuts for 3/4" Bolt	ek
14	3	Suspension Hook	eh
15	3	Suspension Clamp and Connecting Piece	ei
16	6	2 1/4"x 2 1/4" Galv Sq. Washer, 9/16" Hole	
17	2	4"x4"x 3/16" Sq Curved Washer, 15/16" Hole	

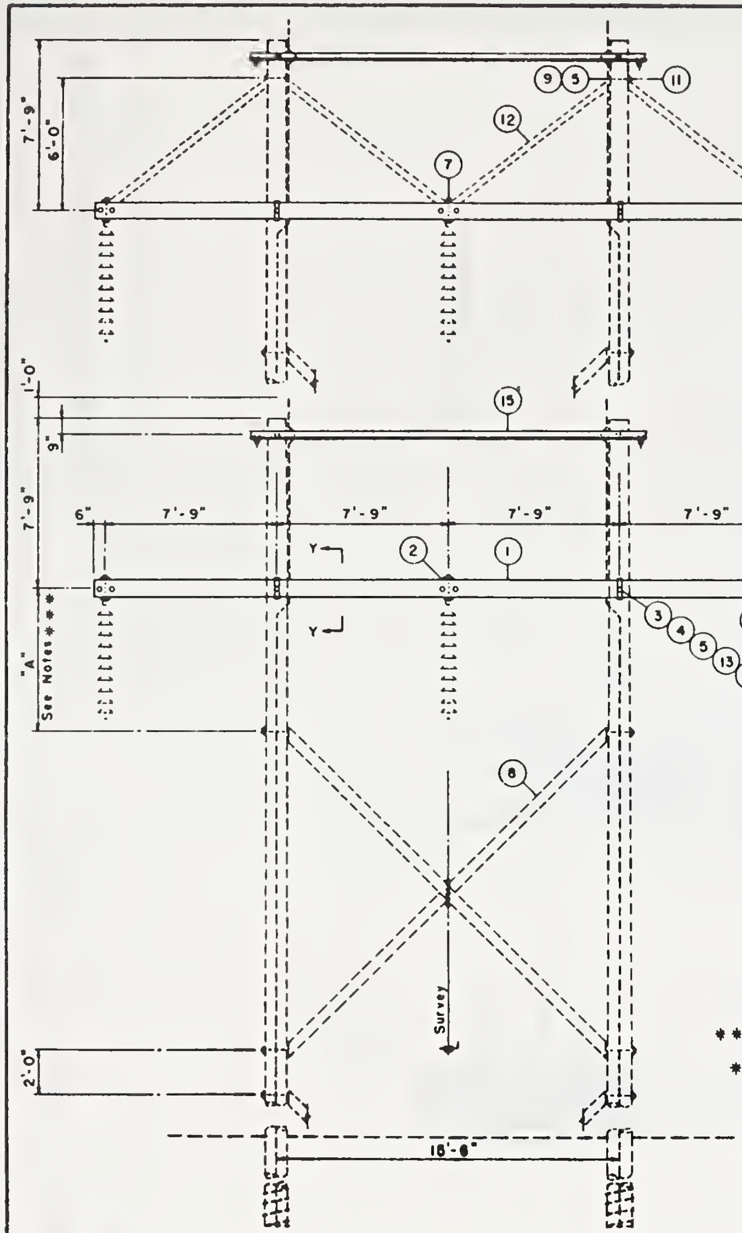
X-BRACED
TRANSMISSION LINE TANGENT STRUCTURE
H-FRAME SUSPENSICN-TWO POLE
(115 KV MAXIMUM)

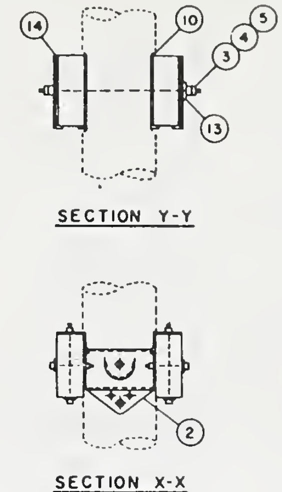
Scale None | Date 11-49 | TH-1A

* As required See Drg TM-1

NO	REVISION	Date
1	REVISED	7-72

Figure 92





NOTES

1. X-braced structures shall have suitable pole foundation to resist uplift.
2. V-braced structures may require guying or X-braces to withstand transverse loads.
3. Use of braces must be economically justified.
4. For other requirements of assemblies refer to Specification T-7.
5. For details of spacers and V-brace fittings see Drg. TM-111.

* 6. For quantities required for other assemblies refer to table, total quantity equals sum of appropriate columns.

** 7. As required, see Drg. TM-1.

8. Cotter keys in insulator strings and clamps shall be oriented in same direction and shall face pole.

**** 9. When specified use alternate type OHGW support and pole tie.

*** 10. Dimension "A" shall be as shown on Drg. TM-104.

11. Any field drilled pole holes shall be pressure treated.
12. Double crossarms shall be shipped complete with factory assembled hardware.

! CROSSARM TYPE 71

1	REVISED	7-72

DESCRIPTION OF ASSEMBLIES

TH-10	No braces
TH-10X	One X-brace
TH-10VO	2-Vee braces outside poles
TH-10VOX	Same as TH-10VO with one X-brace
TH-10VI	2-Vee braces inside poles
TH-10VIX	Same as TH-10VI with one X-brace
TH-10V4	4-Vee braces
TH-10V4X	Same as TH-10V4 with one X-brace
X	One cross brace
XX	Two cross braces

LIST OF MATERIALS - TH-10

ORG REF.	REQ'D.	DESCRIPTION	ITEM
1	2	Crossarm, 3 5/8" x 9 3/8" x 32'-0" long !	gy
2	3	Spacer Fitting Assembly, separation as req'd	
3	2	Threaded rod 7/8" x req'd length	
4	4	Nut for 7/8" bolt	
5	4 *	Locknut for 7/8" bolt, MF type	
6	*	Bent Bolt, 7/8" x 5 1/2" with thd. washer & nut	
7	*	Bent Stud, 7/8" x 8" with th'd washer & nut	
8	*	X-brace Assembly, TM-110	
9	*	Machine Bolt, 7/8" x req'd length	
10	4	Gain Plate 3" x 9 1/2" x 1/4"	
11	*	Curved Washer 4" x 4" x 1/4" x 15/16" hole	
12	*	V-braces, 3 3/8" x 5 3/8" x req'd length	
13	2	Spring Washer, 15/16" hole	
14	4	Ribbed Tie Plate, 3" x 9 1/2" x 1/4"	
15	1	OHGW Support Assembly TM-109 ****	
16	3	Suspension Hook	sh
17	3	Suspension Clamp and Connecting Piece	el
18	**	Suspension Insulator, 5 3/4" x 10, 15000# M&E	k

MATERIALS REQ'D. FOR OTHER ASSEMBLIES

ORG REF.	TH-10VO		TH-10VI		TH-10V4		X		XX	
	REQ'D	ITEM	REQ'D	ITEM	REQ'D	ITEM	REQ'D	ITEM	REQ'D	ITEM
TH-10	1		1		1					
5	4	va	4	vi	6	vv				
6	2				2					
7			1		1					
8							1	vx	2	vs
9	2		2		2					
11	2		2							
12	2		2		4					

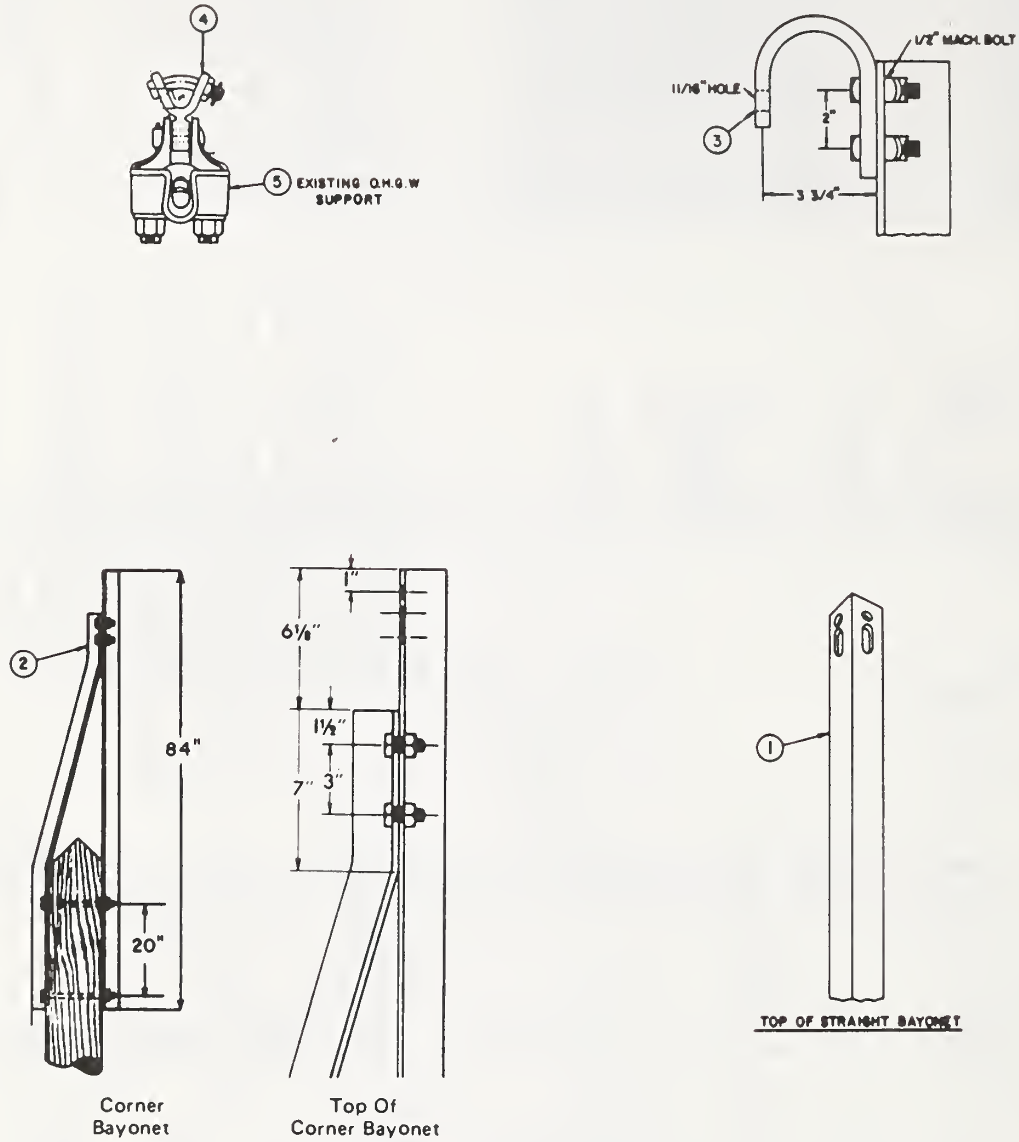
TRANSMISSION LINE TANGENT STRUCTURE
H-FRAME SUSPENSION - TWO POLE
(161 KV. MAXIMUM)

Scale:

Date: 11-30-62

TH-10 SERIES

Figure 93



TYPICAL STEEL BAYONET ASSEMBLY

DATE: 12-80

FIG. 94

LIST OF MATERIALS

DWG. REF.	QTY. REQ.	DESCRIPTION	* ITEM
1 OR 2	1	STEEL BAYONET EXTENSION 3" x 3" x 1/4" x B4"	
1		STRAIGHT BAYONET JOSLIN J1134	
2		CORNER BAYONET JOSLIN J1139	
3	1	GOOSENECK, JOSLIN J2529	
4	1	Y-CLEVIS EYE, CHANCE CS01-0047	
5	1	OVERHEAD GROUNDWIRE SUPPORT CLAMP	m

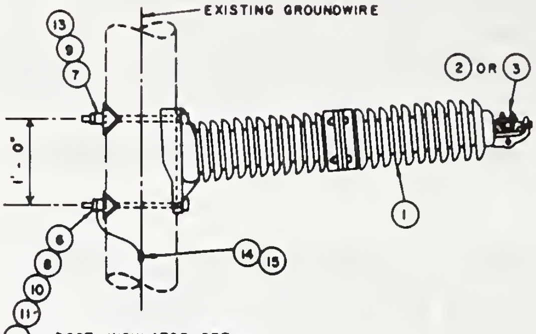
NOTE: DWG. REF. #5, ATTACH AGS UNIT IN A SIMILAR MANNER.

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

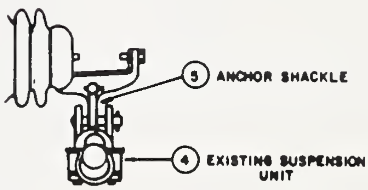
TYPICAL STEEL BAYONET ASSEMBLY

DATE: 12-80

FIG. 95



POST INSULATOR DETAIL



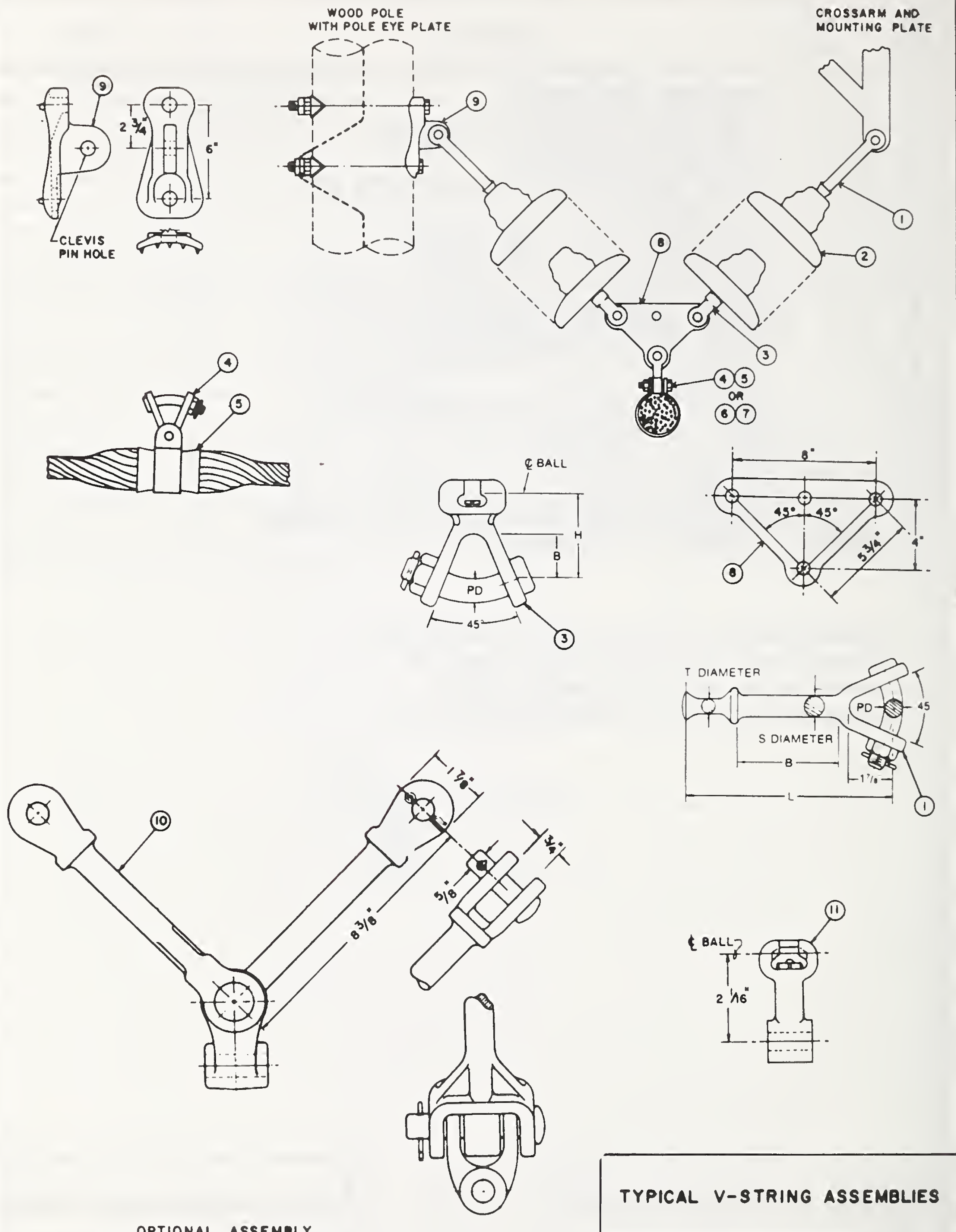
TYPICAL HORIZONTAL POST ASSEMBLY		
DATE: 12 - 80	FIG. 96	

LIST OF MATERIALS

DWG. REF.	QTY. REQ.	DESCRIPTION	* ITEM
1	1	HORIZONTAL POST INSULATOR	ea
2	1	ARMOR GRIP SUPPORT UNIT	
3	1	LINE POST CLAMP (SHOE) WITH ARMOR RODS	
4	1	EXISTING SUSPENSION UNIT	ei
5	1	ANCHOR SHACKLE WITH BOLT, NUT AND COTTER KEY	
		ULT. 30,000#	
6	1	MACHINE BOLT, 5/8" x REQ. LENGTH	c
7	1	MACHINE BOLT, 3/4" x REQ. LENGTH	c
8	1	WASHER, CURVED - 11/16" HOLE, 4" x 4" x 1/4"	
		HUGHES CW-60	
9	1	WASHER CURVED - 13/16" HOLE, 4" x 4" x 1/4"	
		HUGHES CW-70	
10	1	BONDING CLIP FOR 5/8" BOLT HUGHES 2727.6	
11	1	NUT - 5/8" HUGHES N60	
12	1	LOCKNUT (M-F) 5/8" SQ.	ek
13	1	LOCKNUT (M-F) 3/4" SQ.	ek
14	1	COMPRESSION CONNECTOR - ALUMINUM SIZE AS REQUIRED	p
15	AS REQ.	GROUNDWIRE - #6 COPPERWELD	cj

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

TYPICAL HORIZONTAL POST ASSEMBLY		
DATE: 12-80	FIG. 97	



OPTIONAL ASSEMBLY
REPLACE DWG. REF: 3, 4, & 8 WITH 10 & 11

TYPICAL V-STRING ASSEMBLIES

DATE: 12-80	FIG. 98

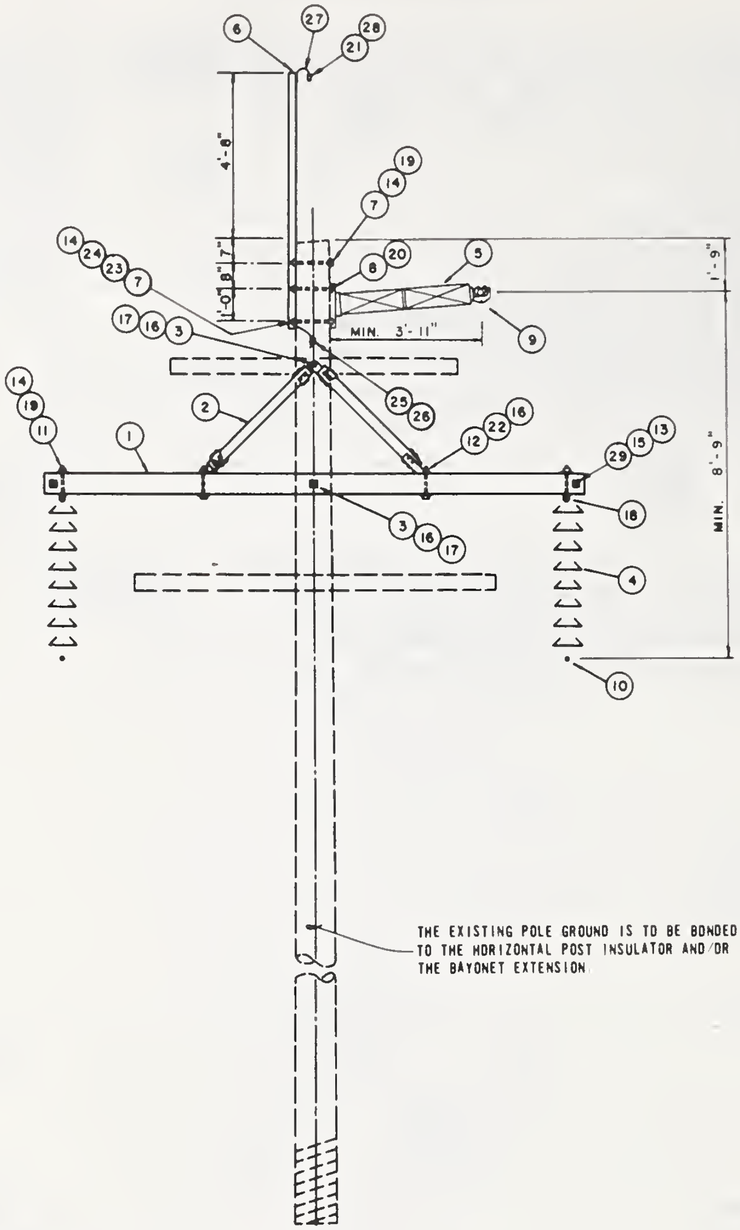
LIST OF MATERIALS

DWG. REF.	QTY REQ.	DESCRIPTION	* ITEM
1	2	Y-CLEVIS BALL, HOT LINE, BATHEA/NATIONAL YCBHL-65	
2	AS REQ.	SUSPENSION INSULATOR, $5\frac{3}{4}$" x 10" 15,000# M & E	
3	2	SOCKET Y-CLEVIS, BREWER TITCHENER 3068	
4	1	AGS Y-CLEVIS EYE	
5	1	AGS UNIT	
6	1	ANCHOR SHACKLE	bo
7	2	SUSPENSION CLAMP	ei
8	1	YOKE PLATE, BREWER TITCHENER 8571	
9	1	POLE EYE PLATE, BETHEA/NATIONAL PE6-87	
10	1	V-STRING CLEVIS-EYE, LAPP # AS REQ.(EX.306350-A-0100)	
11	2	SOCKET EYE, ULT. 25,000#	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

TYPICAL V-STRING ASSEMBLIES

DATE: 12-80 | FIG. 99



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. THE EXISTING CONDUCTOR SUSPENSION CLAMP MAY BE ATTACHED TO THE HORIZONTAL POST INSULATOR WITH AN ANCHOR SHACKLE WHEN SPECIFIED BY THE ENGINEER.

CONVERSION STRUCTURE
TS-1 TO TS-15-HP
(69 KV TO 115 KV)

DATE: 12-80	FIG. 100

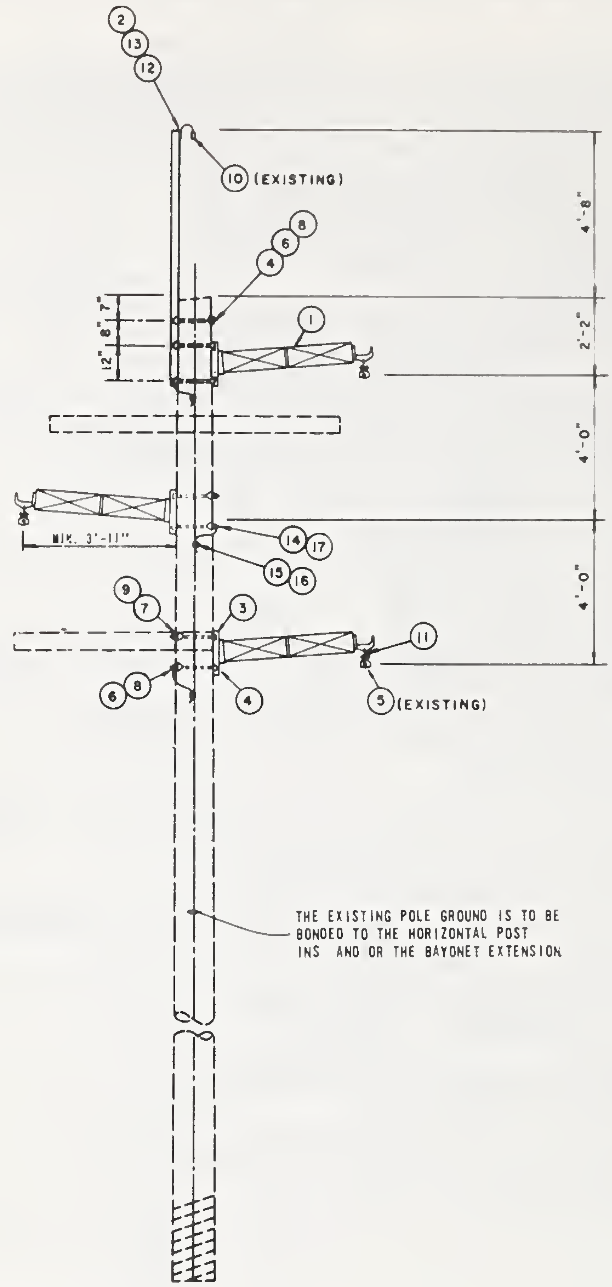
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	1	5 - 5/8" x 7 - 3/8" x 15' WOOD CROSSARM	g
2	1	72" WOOD CROSSARM BRACE, HUGHES #201B	
3	2	7/8" x REQUIRED LENGTH, MACHINE BOLT	c
4	AS REQ'D.	5 - 3/4" x 10" SUSPENSION INSULATOR	k
5	1	HORIZONTAL POST INSULATOR 115KV	ea
6	1	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
7	2	5/8" x REQUIRED LENGTH, MACHINE BOLT	c
8	1	3/4" x REQUIRED LENGTH, MACHINE BOLT	c
9	1	SUSPENSION CLAMP FOR HORIZONTAL POST INS.	
10	2	SUSPENSION CLAMP AND CONNECTING PIECE	ei
11	2	5/8" x 9" EYEBOLT	o
12	2	7/8" x 9" MACHINE BOLT	c
13	2	LOCKNUT FOR 1/2" BOLT	ek
14	4	LOCKNUT FOR 5/8" BOLT	ek
15	2	1 3/8" GALV. ROUND WASHER, 9/16" HOLE	d
16	4	LOCKNUT FOR 7/8" BOLT	ek
17	2	3" x 4" x 7/16" GALV. WASHER, 15/16" HOLE	d
18	2	SUSPENSION HOOK	eh
19	2	3" x 3" x 3/16", GALV. SQ. WASHER, 11/16" HOLE HUGHES SW3-60	
20	1	LOCKNUT FOR 3/4" BOLT	
21	1	SHIELD WIRE CLAMP (AGS UNIT OPTIONAL)	m
22	2	3" x 3" x 3/16" GALV. SQ. WASHER, 15/16" HOLE HUGHES SW3-80	
23	1	NUT - 5/8", HUGHES N60	
24	1	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
25	AS REQ'D	NO. 6 COPPERWELD	cj
26	1	COMPRESSION CONNECTOR FOR GROUNDWIRE	
27	1	GOOSENECK, JOSLIN J2529	
28	1	Y-CLEVIS EYE LAPP 7858, FOR OHGW CLAMP	
29	2	MACHINE BOLT, 1/2" x 7"	C

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TS-1 TO TS-15-HP
(69KV) TO (115KV)

DATE: 12-80 | FIG. 101



NOTES:

1. THE GROUND CLEARANCE MAY BE INCREASED BY MOUNTING THE CONDUCTOR IN A HORIZONTAL POST CLAMP POSITION.
2. THE ENGINEER MAY RELOCATE THE ATTACHMENT POINT OF THE HORIZONTAL POST INSULATORS.
3. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.

CONVERSION STRUCTURE TS-1 TO TS-1-HP (69KV TO 115KV)		
DATE: 12-80	FIG. 102	

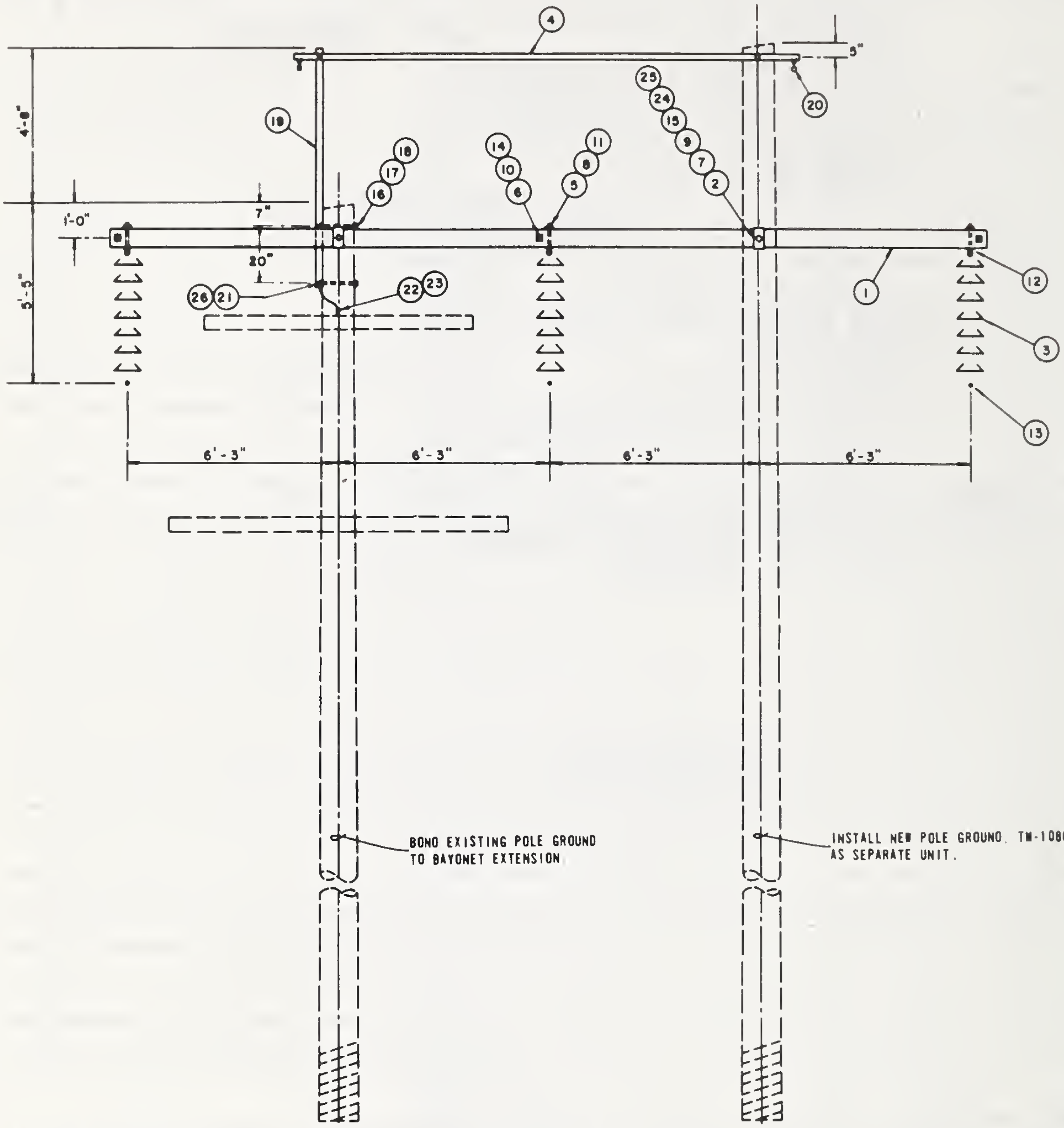
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	3	HORIZONTAL POST INSULATOR, 115KV	ea
2	1	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
3	3	3/4" x REQUIRED LENGTH, MACHINE BOLT	c
4	4	5/8" x REQUIRED LENGTH, MACHINE BOLT	c
5	3	SUSPENSION CLAMP (AGS UNIT OPTIONAL)	ei
6	4	LOCKNUT FOR 5/8" BOLT	ek
7	2	4" x 4" x 1/2" GALV. SQ. WASHER, 13/16" HOLE	d
8	3	3" x 3" x 5/16" GALV. SQ. WASHER, 11/16" HOLE	d
9	3	LOCKNUT FOR 3/4" BOLT	ek
10	1	OHGW SUSPENSION CLAMP (AGS UNIT OPTIONAL)	
11	3	ANCHOR SHACKLE	bo
12	1	GOOSENECK JOSLIN J2529	
13	1	Y-CLEVIS EYE FOR OHGW CLAMP, LAPP 7858	
14	3	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
15	AS REQ'D.	NO. 6 COPPERWELD	cj
16	32	COMPRESSION CONNECTOR FOR GROUNDWIRE	
17	1	NUT - 5/8", HUGHES N60	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TS-1 TO TS-1-HP
(69KV) TO (115KV)

DATE: 12-80 | FIG. 103



NOTES:

1. THE BAYONET EXTENSION, JOSLIN J1134, MAY BE MOUNTED TO EITHER THE FACE OR THE SIDE OF THE POLE AS DETERMINED BY THE ENGINEER.
2. WOOD POLE GAINING AND GAIN PLATES MAY BE ELIMINATED WITH THE INSTALLATION OF GRID GAINS (BETHEA/NATIONAL CAG-54-7) WHEN SPECIFIED BY THE ENGINEER.
3. THE "NEW" POLE MAY BE MATCHED IN HEIGHT WITH THE EXISTING POLE AND INSTALL TWO BAYONET EXTENSION ASSEMBLIES WHEN SPECIFIED BY THE ENGINEER.
4. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
5. THE USE OF CROSSBRACES MUST BE ECONOMICALLY JUSTIFIED.

CONVERSION STRUCTURE TS-1 TO TH-1AM (69KV TO 115KV)		
DATE: 12-80	FIG. 104	

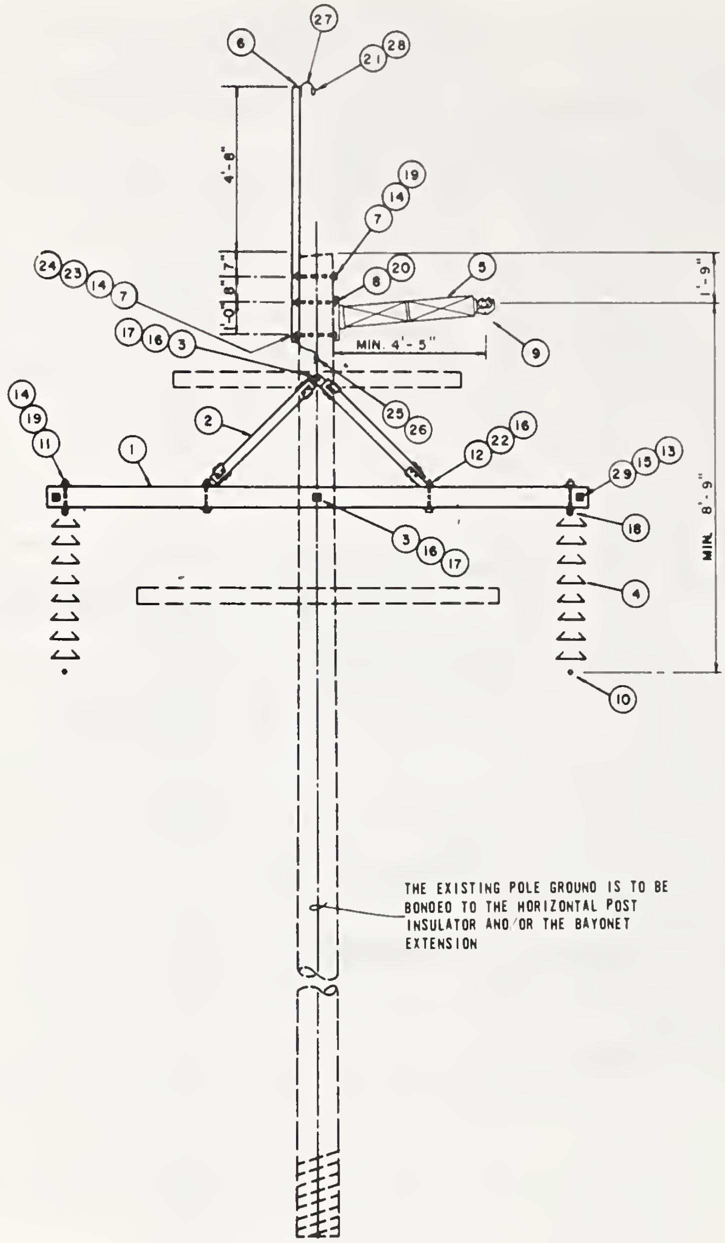
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	1	5 3/8" x 7 5/8" x 26'- 0" WOOD CROSSARM, TYPE 55	g
2	2	RIBBED TIE PLATE HUGHES 1005	_
3	AS REQ.	5 3/4" x 10" SUSPENSION INSULATOR	k
4	1	OHGW SUPPORT ASSEMBLY TM-109, EXCEPT TIE ANGLE IS	
		3 1/2" x 3" x 1/4" x 15'- 0"	
5	3	3/4" x 10" EYE BOLT	o
6	3	1/2" x 8" MACHINE BOLT	c
7	2	7/8" x REQUIRED LENGTH, MACHINE BOLT	c
8	3	4" x 4" x 3/16" GALV. SQ. WASHER, 13/16" HOLE	d
9	4	LOCKNUTS FOR 7/8" BOLTS	ek
10	3	LOCKNUTS FOR 1/2" BOLTS	ek
11	3	LOCKNUTS FOR 3/4" BOLTS	ek
12	3	SUSPENSION HOOK	eh
13	3	SUSPENSION CLAMP AND CONNECTING PIECE	ei
14	3	2 1/4" x 2 1/4" GALV. SQ. WASHER, 9/16" HOLE HUGHES SW 2¼-60	
15	2	3" x 4" x 7/16" CURVED WASHER, 15/16" HOLE	d
16	2	5/8" x REQUIRED LENGTH MACHINE BOLT	
17	2	CURVED WASHER, 11/16" HOLE, 4" x 4" SQ. HUGHES CW-60	
18		LOCKNUT FOR 5/8" BOLT	
19	1	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
20	2	GROUNDWIRE SUSPENSION CLAMP	m
21	1	BONDING CLIP FOR 5/8" BOLT HUGHES 2727.6	
22	AS REQ.	NO. 6 COPPERWELD	cj
23	1	COMPRESSION CONNECTOR FOR GROUNDWIRE	
24	2	GAIN PLATE, HUGHES 1004	
25	2	SPRING WASHER	aw
26	1	NUT 5/8", HUGHES N60	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TS-1 TO TH-1AM
(69KV) TO (115KV)

DATE: 12-80 | FIG. 105



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. THE EXISTING CONDUCTOR SUSPENSION CLAMP MAY BE ATTACHED TO THE HORIZONTAL POST INSULATOR WITH AN ANCHOR SHACKLE WHEN SPECIFIED BY THE ENGINEER.

CONVERSION STRUCTURE TS-1 TO TS-15-HP (69 KV TO 138KV)		
DATE: 12-80	FIG. 106	

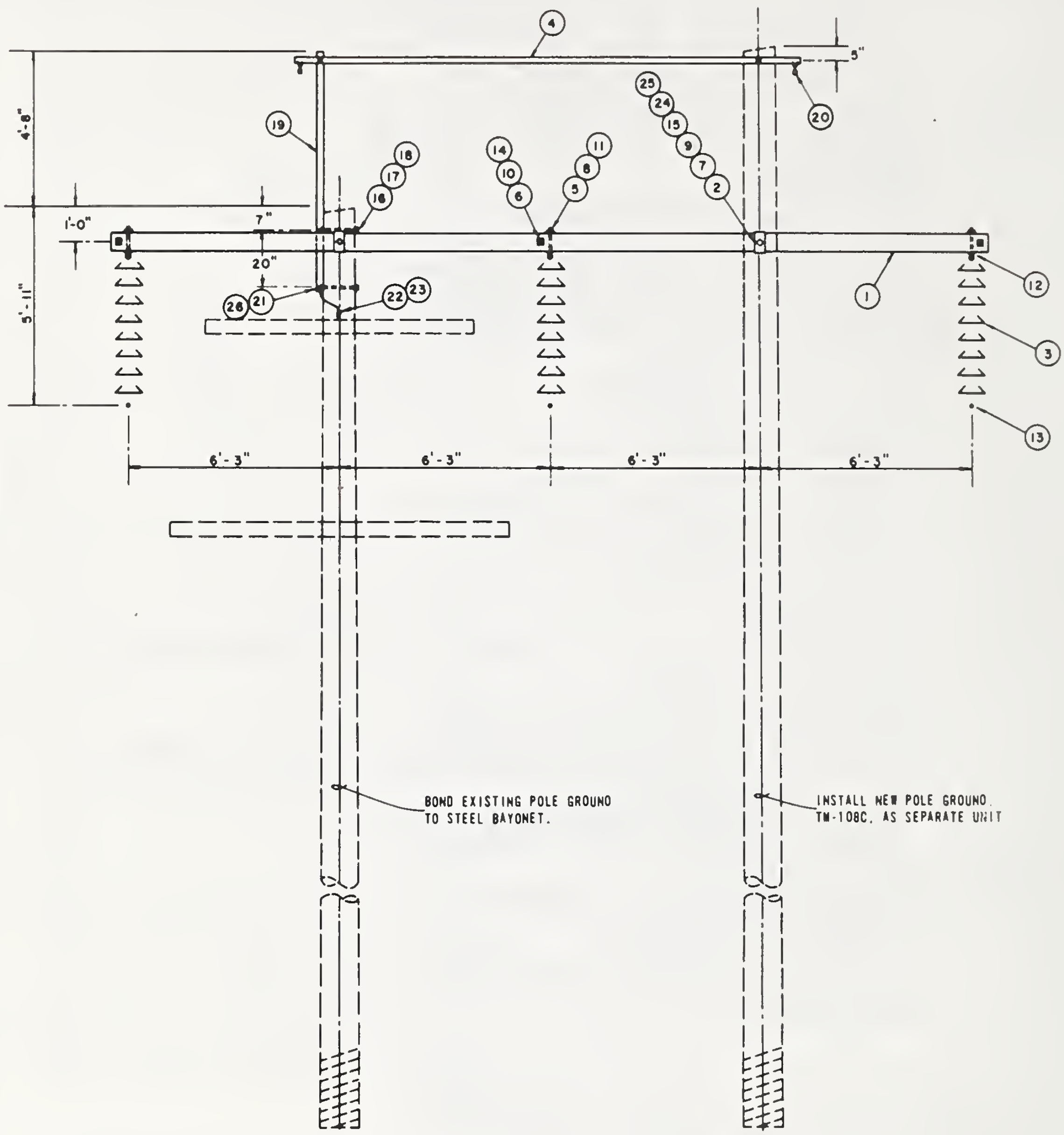
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	1	5 - 5/8" x 7 3/B" x 15' WOOO CROSSARM	g
2	1	72" WOOO CROSSARM BRACE, HUGHES #201B	
3	2	7/B" x REQUIRED LENGTH, MACHINE BOLT	c
4	AS REQ.	5 3/4" x 10" SUSPENSION INSULATOR	
5	1	HORIZONTAL POST INSULATOR 138KV LAPP 70148	
6	1	STEEL BAYONET, 3" x 3" x 1/4" x B4", JOSLYN #1134	
7	2	5/B" x REQUIREO LENGTH, MACHINE BOLT	c
8	1	3/4" x REQUIREO LENGTH, MACHINE BOLT	c
9	1	SUSPENSION CLAMP FOR HORIZONTAL POST INS.	
10	2	SUSPENSION CLAMP AND CONNECTING PIECE	ei
11	2	5/8" x 9" EYEBOLT	o
12	2	7/8" x 9" MACHINE BOLT	c
13	2	LOCKNUT FOR 1/2" BOLT	ek
14	4	LOCKNUT FOR 5/8" BOLT	ek
15	2	1 3/B" GALV. ROUNO WASHER, 9/16" HOLE	d
16	4	LOCKNUT FOR 7/8" BOLT	ek
17	2	3" x 4" x 7/16" GALV.	d
18	2	SUSPENSION HOOK	eh
19	2	3" x 3" x 3/16", GALV. SQ. WASHER, 11/16" HOLE HUGHES SW3-60	
20	1	LOCKNUT FOR 3/4" BOLT	ek
21	1	SHIELD WIRE CLAMP (AGS UNIT OPTIONAL)	m
22	2	3" x 3" x 3/16" GALV. SQ. WASHER, 15/16" HOLE, HUGHES SW3-80	
23	1	NUT - 5/8" HUGHES N60	
24	1	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
25	AS REQ.	NO. 6 COPPERWELD	cj
26	1	COMPRESSION CONNECTOR FOR GROUNDWIRE	
27	1	GOOSENECK, JOSLIN J2529	
2B	1	Y-CLEVIS EYE, LAPP 7B58 FOR OHGW CLAMP	
29	2	MACHINE BOLT, 1/2" x 7"	c

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USEO.

CONVERSION STRUCTURE
TS-1 TO TS-15-HP
(69KV) TO (138KV)

DATE: 12-80 | FIG. 107



NOTES:

1. THE BAYONET EXTENSION, JOSLIN J1134, MAY BE MOUNTED TO EITHER THE FACE OR THE SIDE OF THE POLE AS DETERMINED BY THE ENGINEER.
2. WOOD POLE GAINING AND GAIN PLATES MAY BE ELIMINATED WITH THE INSTALLATION OF GRID GAINS (BETHEA/NATIONAL CAG-54-7) WHEN SPECIFIED BY THE ENGINEER.
3. THE "NEW" POLE MAY BE MATCHED IN HEIGHT WITH THE EXISTING POLE AND INSTALL TWO BAYONET EXTENSION ASSEMBLIES WHEN SPECIFIED BY THE ENGINEER.
4. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
5. THE USE OF CROSSBRACES MUST BE ECONOMICALLY JUSTIFIED.

CONVERSION STRUCTURE TS-1 TO TH-1AM (69KV TO 138KV)		
DATE: 12 - 80	FIG. 108	

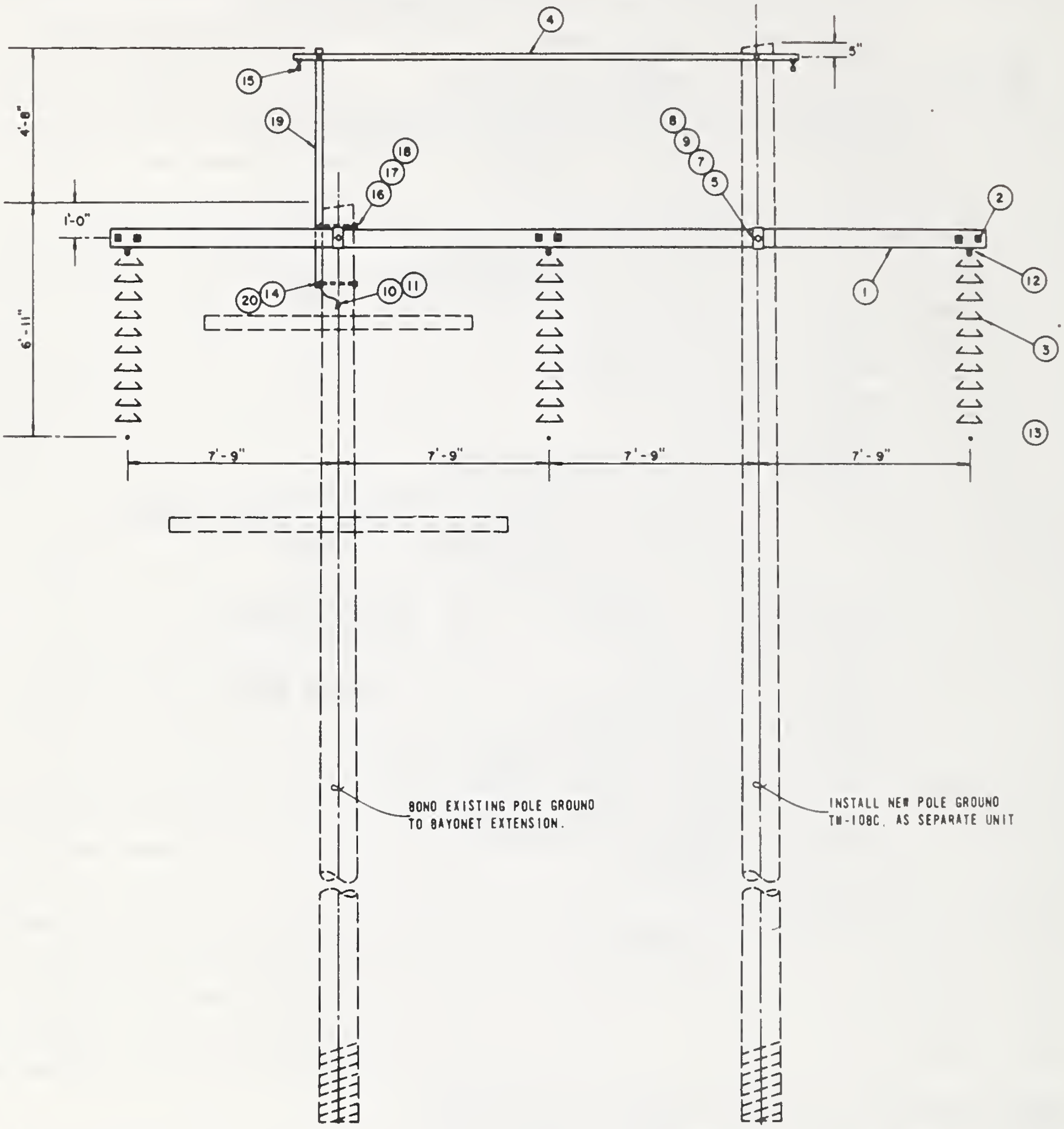
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	1	5 3/8" x 7 5/8" x 26'- 0" WOOD CROSSARM, TYPE 55	g
2	2	RIBBED TIE PLATE HUGHES 1005	
3	AS REQ.	5 3/4" x 10" SUSPENSION INSULATOR	k
4	1	OHGW SUPPORT ASSEMBLY TM-109, EXCEPT TIE ANGLE IS	
		3 1/2" x 3" x 1/4" x 15'-0"	
5	3	3/4" x 10" EYE BOLT	o
6	3	1/2" x 8" MACHINE BOLT	c
7	2	7/8" x REQUIRED LENGTH, MACHINE BOLT	c
8	3	4" x 4" x 3/16" GALV. SQ. WASHER, 13/16" HOLE	d
9	4	LOCKNUTS FOR 7/8" BOLTS	ek
10	3	LOCKNUTS FOR 1/2" BOLTS	ek
11	3	LOCKNUTS FOR 3/4" BOLTS	ek
12	3	SUSPENSION HOOK	eh
13	3	SUSPENSION CLAMP AND CONNECTING PIECE	ei
14	3	2 1/4" x 2 1/4" GALV. SQ. WASHER, 9/16" HOLE HUGHES SW2¼-60	
15	2	3" x 4" x 7/16" CURVED WASHER, 15/16" HOLE	d
16	2	5/8" REQUIRED LENGTH MACHINE BOLT	
17	2	CURVED WASHER, 11/16" HOLE 4" x 4" SQ. HUGHES CW-60	
18	2	LOCKNUT FOR 5/8" BOLT	
19	1	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
20	2	GROUNDWIRE SUSPENSION CLAMP	m
21	1	BONDING CLIP FOR 5/8" BOLT HUGHES 2727.6	
22	AS REQ.	NO. 6 COPPERWELD	cj
23	1	COMPRESSION CONNECTOR FOR GROUNDWIRE	
24	2	GAIN PLATE HUGHES 1004	
25	2	SPRING WASHER	aw
26	1	NUT - 5/8" HUGHES N60	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TS-1 TO TH-1AM
(69KV) TO (138KV)

DATE: 12-80 | FIG. 109



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. WOOD POLE GAINING AND GAIN PLATES MAY BE ELIMINATED WITH THE INSTALLATION OF GRID GAINS (BETHEA/NATIONAL CAG-54-7) WHEN SPECIFIED BY THE ENGINEER.
3. THE "NEW" POLE MAY BE MATCHED IN HEIGHT WITH THE EXISTING POLE AND INSTALL TWO BAYONET EXTENSION ASSEMBLIES WHEN SPECIFIED BY THE ENGINEER.
4. CROSSBRACES MAY BE INSTALLED WHEN SPECIFIED BY THE ENGINEER.

CONVERSION STRUCTURE TS-1 TO TH-10M (69KV TO 161KV)	
DATE: 12-80	FIG. 110

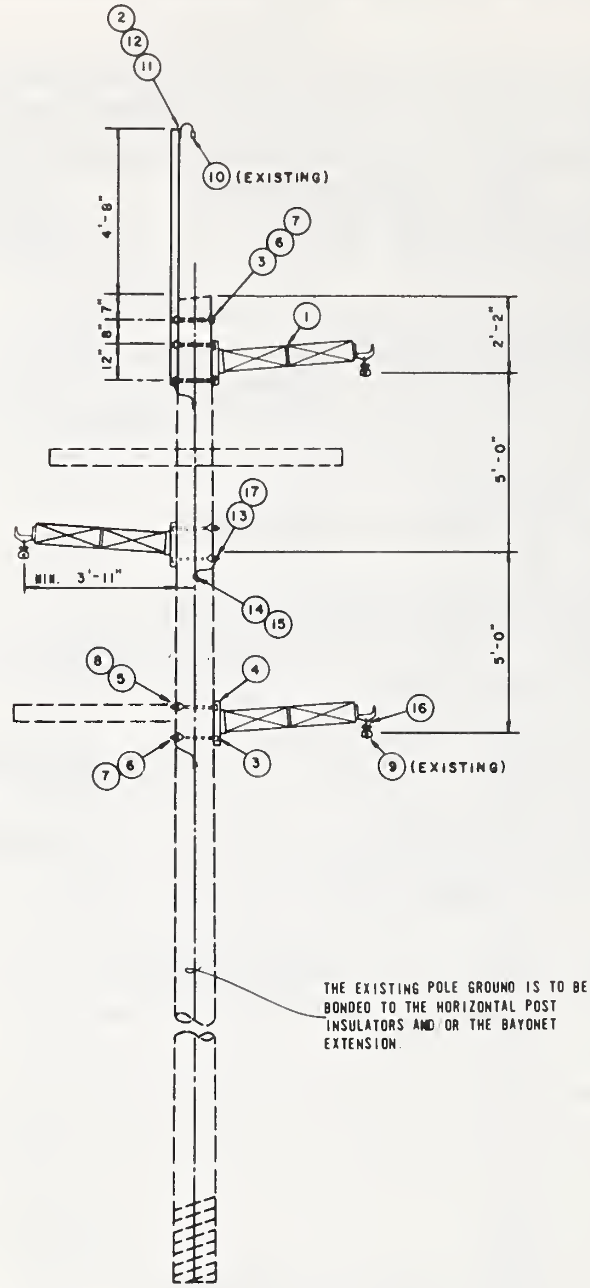
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	2	3 5/8" x 9 3/8" x 32'- 0" WOOD CROSSARM, TYPE 71	g
2	3	SPACER FITTING ASSEMBLY, SEPARATION AS REQUIRED	
3	AS REQ'D.	5 3/4" x 10" SUSPENSION INSULATOR	k
4	1	OHGW SUPPORT ASSEMBLY TM-109, TIE ANGLE IS	
		3 1/2" x 3" x 1/4" x 18'- 0"	
5	4	GAIN PLATE, 3" x 9½" x 1/4", HUGHES 1004	
6	2	SPRING WASHER 15/16" HOLE	aw
7	2	7/8" x REQUIRED LENGTH, THREADED ROD	
8	4	RIBBED TIE PLATE, 3" x 9½" x 1/4" HUGHES 1005	
9	4	LOCKNUTS FOR 7/8" BOLTS	ek
10	AS REQ'D.	NO. 6 COPPERWELD	cj
11	1	COMPRESSION CONNECTOR FOR GROUNDWIRE	
12	3	SUSPENSION HOOK	eh
13	3	SUSPENSION CLAMP AND CONNECTING PIECE	ei
14	1	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
15	2	OHGW SUSPENSION CLAMP	m
16	2	5/8" x REQUIRED LENGTH MACHINE BOLT	c
17	2	CURVED WASHER, 11/16" HOLE 4" x 4" SQ. HUGHES CW-60	
18	2	LOCKNUT FOR 5/8" BOLT	ek
19	1	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
20	1	NUT - 5/8", HUGHES N60	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TS-1 TO TH-10M
(69KV TO 161 KV)

DATE: 12-80 | FIG. 111



NOTES:

1. THE GROUND CLEARANCE MAY BE INCREASED BY MOUNTING THE CONDUCTOR IN A HORIZONTAL POST CLAMP POSITION.
2. THE ENGINEER MAY RELOCATE THE ATTACHMENT POINT OF THE HORIZONTAL POST INSULATORS.
3. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.

CONVERSION STRUCTURE TS-1X TO TS-1X-HP (69KV TO 115KV)		
DATE: 12-80	FIG. 112	

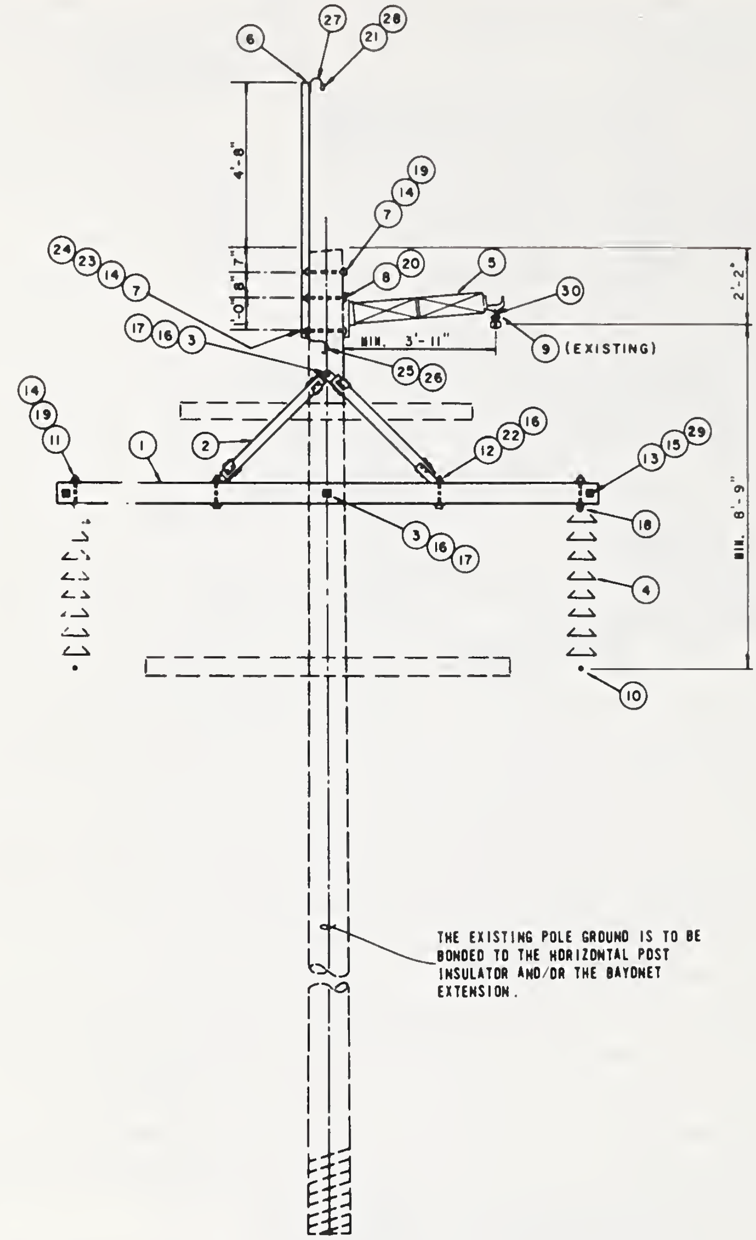
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	3	HORIZONTAL POST INSULATOR 115KV	ea
2	1	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
3	4	5/8" x REQUIRED LENGTH, MACHINE BOLT	c
4	3	3/4" x REQUIRED LENGTH, MACHINE BOLT	c
5	2	CURVED WASHER, 13/16" HOLE 4" x 4" x 1/2"	d
6	3	CURVED WASHER, 11/16" HOLE 3" x 3" x 5/16"	d
7	4	LOCKNUT FOR 5/8" BOLTS	ek
8	3	LOCKNUT FOR 3/4" BOLTS	ek
9	3	SUSPENSION CLAMP (AGS UNIT OPTIONAL).	ei
10	1	OHGW SUSPENSION CLAMP (AGS UNIT OPTIONAL)	
11	1	GOOSENECK, JOSLIN J2529	
12	1	Y-CLEVIS EYE FOR OHGW CLAMP LAPP 7858	
13	3	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
14	AS REQ.	NO. 6 COPPERWELD	cj
15	3	COMPRESSION CONNECTOR FOR GROUNDWIRE	
16	3	ANCHOR SHACKLE	bo
17	3	NUT - 5/8", HUGHES N60	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TS-1X TO TS-1X-HP
(69KV TO 115KV)

DATE: 12-80 | FIG. 113



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. ADDITIONAL GROUND CLEARANCE MAY BE OBTAINED BY MOUNTING THE CONDUCTOR IN A HORIZONTAL POST CLAMP POSITION.

CONVERSION STRUCTURE TS-1X TO TS-15X-HP (69 KV TO 115 KV)		
DATE: 12-80	FIG. 114	

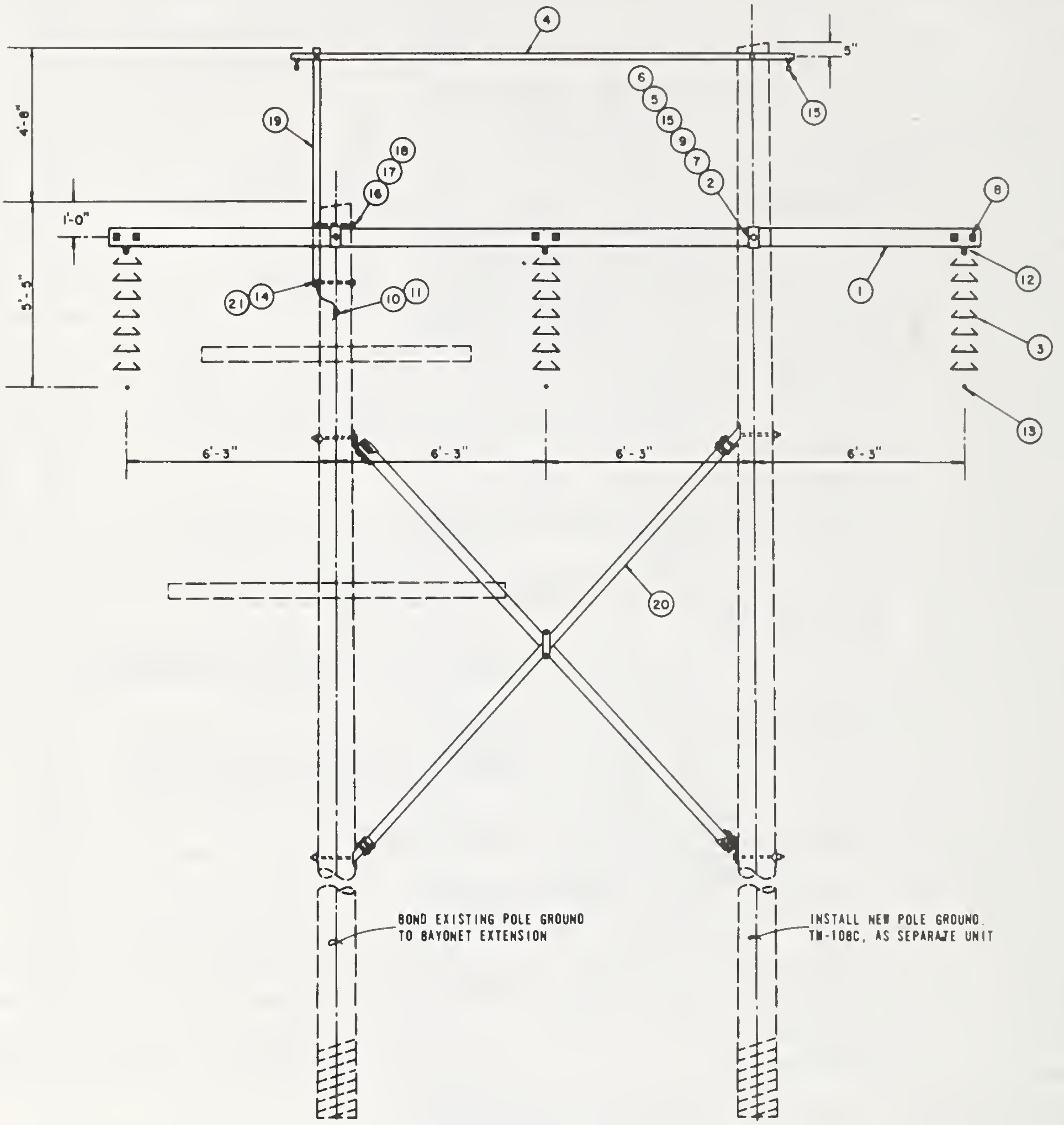
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	1	5 5/8" x 7 3/B" x 15' WOOD CROSSARM	g
2	1	72" WOOD CROSSARM BRACE, HUGHES #201B	
3	2	7/B" x REQUIREO LENGTH, MACHINE BOLT	c
4	AS REQ.	5 3/4" x 1D" SUSPENSION INSULATOR	
5	1	HORIZONTAL POST INSULATOR 115KV	ea
6	1	STEEL BAYONET, 3" x 3" x 1/4" x B4", JOSLYN #1134	
7	2	5/B" x REQUIRED LENGTH, MACHINE BOLT	c
B	1	3/4" x REQUIREO LENGTH, MACHINE BOLT	c
9	1	SUSPENSION CLAMP (AGS, UNIT OPTIONAL)	
10	2	SUSPENSION CLAMP ANO CONNECTING PIECE	ei
11	2	5/8" x 9" EYEBOLT	o
12	2	7/B" x 9" MACHINE BOLT	c
13	2	LOCKNUT FOR 1/2" BOLT	ek
14	4	LOCKNUT FOR 5/8" BOLT	ek
15	2	1 3/8" GALV. ROUND WASHER, 9/16" HOLE	d
16	4	LOCKNUT FOR 7/8" BOLT	ek
17	2	3" x 4" x 7/16" GALV. WASHER, 15/16" HOLE	d
18	2	SUSPENSION HOOK	eh
19	2	3" x 3" x 3/16", GALV. SQ. WASHER, 11/16" HOLE HUGHES SW3-60	
20	1	LOCKNUT FOR 3/4" BOLT	ek
21	1	SHIELO WIRE CLAMP (AGS UNIT OPTIONAL)	m
22	2	3" x 3" x 3/16" GALV. SQ. WASHER 15/16" HOLE HUGHES SW3-80	
23	1	NUT-5/8" HUGHES N 60	
24	1	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
25	AS REQ.	NO. 6 COPPERWELD	cj
26	1	COMPRESSION CONNECTOR FOR GROUNDWIRE	
27	1	GOOSENECK, JOSLIN J2529	
28	1	Y-CLEVIS, EYE, LAPP 7858, FOR OHGW CLAMP	
29	2	MACHINE BOLT, 1/2" x 7"	c
30	1	ANCHOR SHACKLE	bo

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY COOE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. ANO CATALOG NO. ARE SPECIFIEO TO IOENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTEO MAY BE USEO.

CONVERSION STRUCTURE
TS-1X TO TS-15X-HP
(69KV) TO (115KV)

DATE: 12-80 | FIG. 115



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. WOOD POLE GAINING AND GAIN PLATES MAY BE ELIMINATED WITH THE INSTALLATION OF GRID GAINS (BETHEA/NATIONAL CAG-54-7) WHEN SPECIFIED BY THE ENGINEER.
3. THE "NEW" POLE MAY BE MATCHED IN HEIGHT WITH THE EXISTING POLE AND INSTALL TWO BAYONET EXTENSION ASSEMBLIES WHEN SPECIFIED BY THE ENGINEER.
4. THE LOCATION AND QUANTITY OF CROSSBRACES IS TO BE DETERMINED BY THE ENGINEER.

CONVERSION STRUCTURE TS-1X TO TH-1AAXM (69KV TO 115KV)		
DATE: 12-80	FIG. 116	

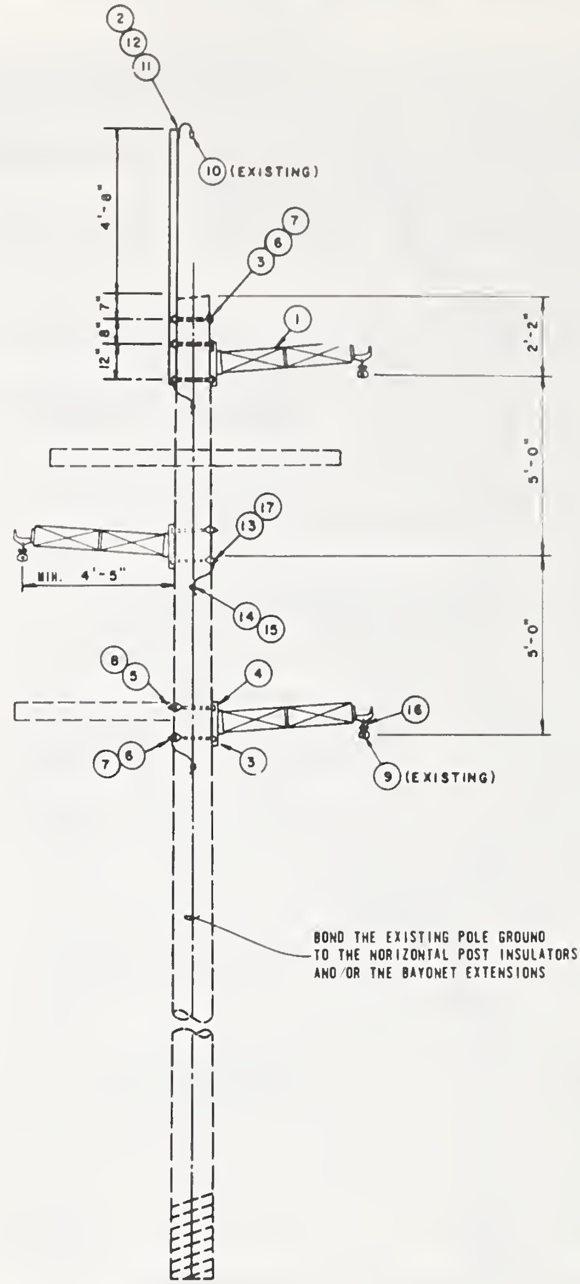
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	2	3 5/8" x 9 3/8" x 26'- 0" WOOD CROSSARM, TYPE 54	g
2	4	RIBBED TIE PLATE HUGHES 1005	
3	AS REQ.	5 3/4" x 10" SUSPENSION INSULATOR	k
4	1	OHGW SUPPORT ASSEMBLY TM-109, EXCEPT TIE ANGLE IS	
		3 1/2" x 3" x 1/4" x 15'- 0"	
5	4	GAIN PLATE, HUGHES 1004	
6	2	SPRING WASHER	aw
7	2	7/8" x REQUIRED LENGTH, THREADED ROD	
8	3	SPACER FITTING ASSEMBLY, SEPARATION, AS REQUIRED	
9	4	LOCKNUTS FOR 7/8" BOLTS	ek
10	AS REQ.	NO. 6 COPPERWELD	cj
11	1	COMPRESSION CONNECTOR FOR GROUNDWIRE	
12	3	SUSPENSION HOOK	eh
13	3	SUSPENSION CLAMP AND CONNECTING PIECE	ei
14	1	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
15	2	OHGW SUSPENSION CLAMP	m
16	2	5/8" x REQUIRED LENGTH MACHINE BOLT	c
17	2	CURVED WASHER, 11/16" HOLE 4" x 4" SQ. HUGHES CW-60	
18	2	LOCKNUT FOR 5/8" BOLT	ek
19	1	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
20	1	X-BRACE ASSEMBLY, TM-110	
21	1	NUT - 5/8", HUGHES N60	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TS-1X TO TH-1AAXM
(69KV TO 115KV)

DATE: 12-80 | FIG. 117



NOTES:

1. THE GROUND CLEARANCE MAY BE INCREASED BY MOUNTING THE CONDUCTOR IN A HORIZONTAL POST CLAMP POSITION
2. THE ENGINEER MAY RELOCATE THE ATTACHMENT POINT OF THE HORIZONTAL POST INSULATORS.
3. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.

CONVERSION STRUCTURE
TS-1X TO TS-1X-HP
(69KV TO 138KV)

DATE: 12-80

FIG. 118

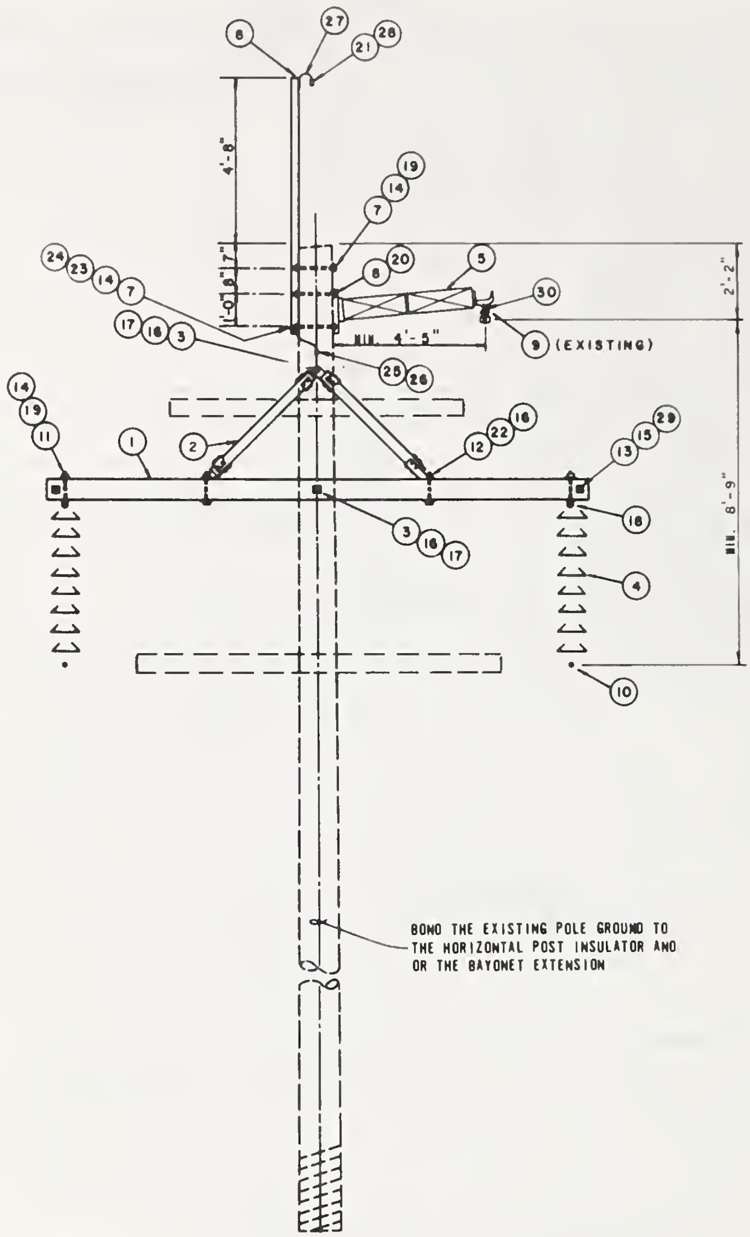
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	ITEM
1	3	HORIZONTAL POST INSULATOR 138KV LAPP 70148	
2	1	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
3	4	5/8" x REQUIRED LENGTH, MACHINE BOLT	c
4	3	3/4" x REQUIRED LENGTH, MACHINE BOLT	c
5	2	CURVED WASHER, 13/16" HOLE 4" x 4" x 1/2"	d
6	3	CURVED WASHER, 11/16" HOLE 3" x 3" x 5/16"	d
7	4	LOCKNUT FOR 5/8" BOLTS	ek
8	3	LOCKNUT FOR 3/4" BOLTS	ek
9	3	SUSPENSION CLAMP (AGS UNIT OPTIONAL)	ei
10	1	OHGW SUSPENSION CLAMP (AGS UNIT OPTIONAL)	
11	1	GOOSENECK, JOSLIN J2529	
12	1	Y-CLEVIS EYE FOR OHGW CLAMP LAPP 7858	
13	3	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
14	AS REQ.	NO. 6 COPPERWELD	cj
15	3	COMPRESSION CONNECTOR FOR GROUNDWIRE	
16	3	ANCHOR SHACKLE	bo
14	3	NUT - 5/8", HUGHES N60	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TS-1X TO TS-1X-HP
(69KV TO 138KV)

DATE:12-80 | FIG. 119



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. ADDITIONAL GROUND CLEARANCE MAY BE OBTAINED BY MOUNTING THE CONDUCTOR IN A HORIZONTAL POST CLAMP POSITION.

CONVERSION STRUCTURE
TS-1X TO TS-15X-HP
(69 KV TO 138 KV)

DATE: 12-80	FIG. 120

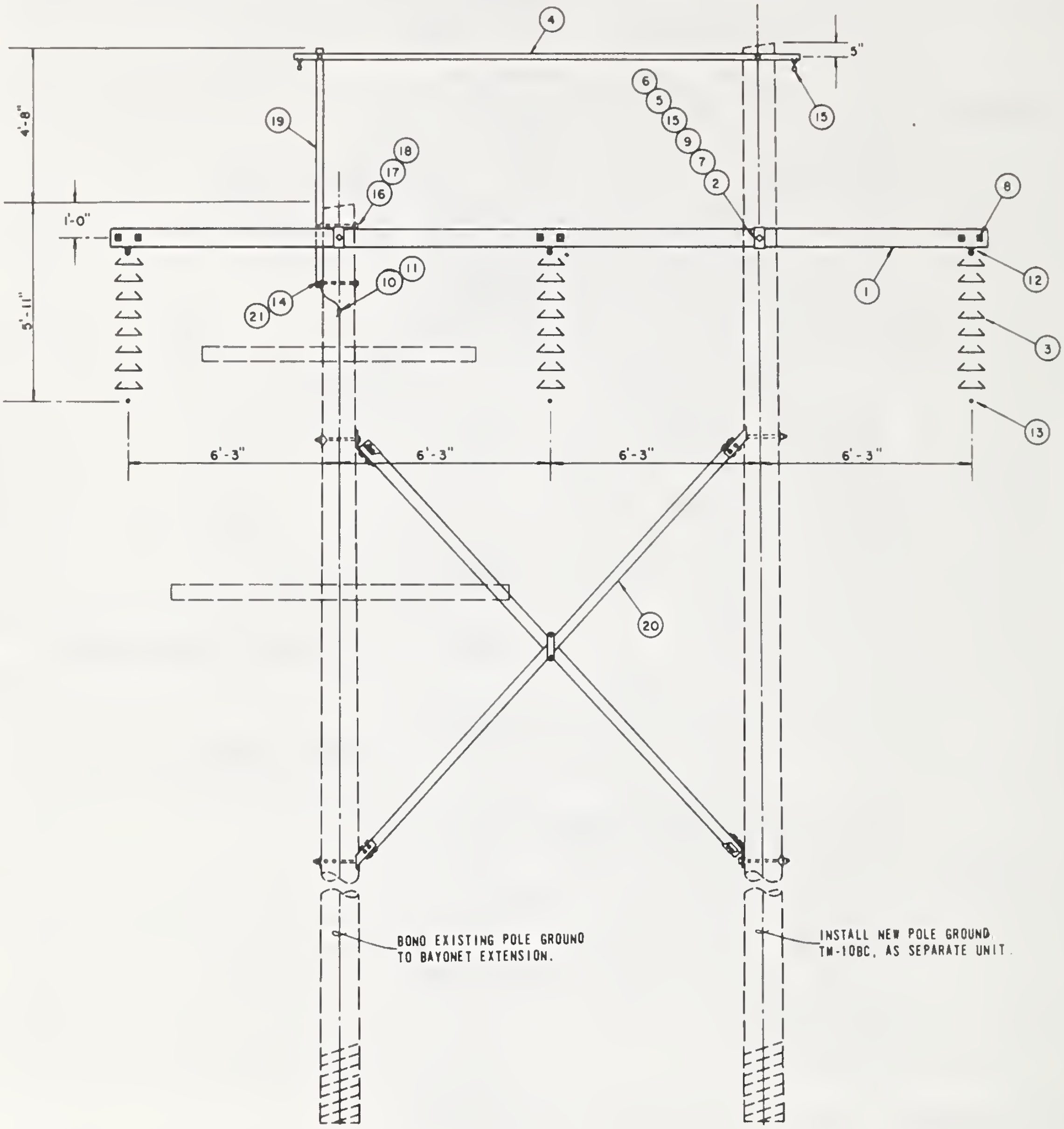
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	1	5 5/8" x 7 3/8" x 15' WOOD CROSSARM	g
2	1	72" WOOD CROSSARM BRACE, HUGHES #201B	
3	2	7/8" x REQUIRED LENGTH, MACHINE BOLT	c
4	AS REQ.	5 3/4" x 10" SUSPENSION INSULATOR	
5	1	HORIZONTAL POST INSULATOR 138KV LAPP 70148	
6	1	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
7	2	5/8" x REQUIRED LENGTH, MACHINE BOLT	c
8	1	3/4" x REQUIRED LENGTH, MACHINE BOLT	c
9	1	SUSPENSION CLAMP (AGS UNIT OPTIONAL)	
10	2	SUSPENSION CLAMP AND CONNECTING PIECE	ei
11	2	5/8" x 9" EYEBOLT	o
12	2	7/8" x 9" MACHINE BOLT	c
13	2	LOCKNUT FOR 1/2" BOLT	ek
14	4	LOCKNUT FOR 5/8" BOLT	ek
15	2	1 3/8" GALV. ROUND WASHER, 9/16" HOLE	d
16	4	LOCKNUT FOR 7/8" BOLT	ek
17	2	3" x 4" x 7/16" GALV. SQ. WASHER, 15/16" HOLE	d
18	2	SUSPENSION HOOK	eh
19	2	3" x 3" x 3/16", GALV. SQ. WASHER, 11/16" HOLE, HUGHES SW3-60	
20	1	LOCKNUT FOR 3/4" BOLT	ek
21	1	SHIELD WIRE CLAMP (AGS UNIT OPTIONAL)	
22	2	3" x 3" x 3/16" GALV. SQ. WASHER, 15/16" HOLE, HUGHES SW 3-80	
23	1	NUT - 5/8" HUGHES N60	
24	1	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
25	AS REQ.	NO. 6 COPPERWELD	cj
26	1	COMPRESSION CONNECTOR FOR GROUNDWIRE	
27	1	GOOSENECK, JOSLIN J 2529	
28	1	Y-CLEVIS EYE LAPP 7858, FOR OHGW CLAMP	
29	2	MACHINE BOLT 1/2" x 7"	c
30	1	ANCHOR SHACKLE	bo

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TS-1X TO TS-15X-HP
(69KV) TO (138KV)

DATE: 12-80 | FIG. 121



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. WOOD POLE GAINING AND GAIN PLATES MAY BE ELIMINATED WITH THE INSTALLATION OF GRID GAINS (BETHEA NATIONAL CAG-54-7) WHEN SPECIFIED BY THE ENGINEER.
3. THE "NEW" POLE MAY BE MATCHED IN HEIGHT WITH THE EXISTING POLE AND INSTALL TWO BAYONET EXTENSION ASSEMBLIES WHEN SPECIFIED BY THE ENGINEER.
4. THE LOCATION AND QUANTITY OF CROSSBRACES IS TO BE DETERMINED BY THE ENGINEER.

CONVERSION STRUCTURE TS-1X TO TH-1AAXM (69KV TO 138KV)		
DATE: 12-80	FIG. 122	

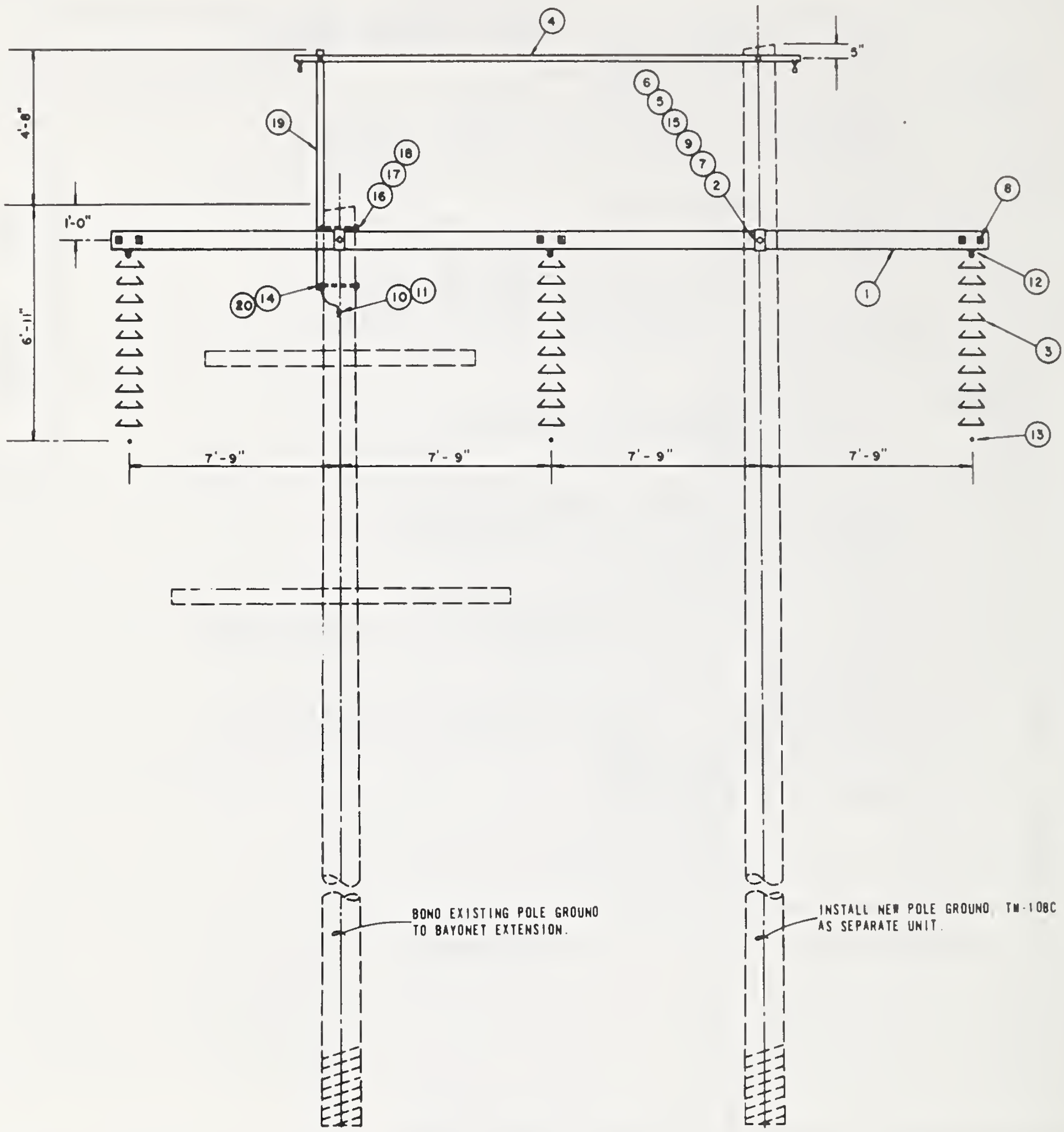
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	2	3 5/8" x 9 3/8" x 26'- 0" WOOD CROSSARM, TYPE 54	g
2	4	RIBBED TIE PLATE, HUGHES 1005	
3	AS REQ'D	5 3/4" x 10" SUSPENSION INSULATOR	k
4	1	OHGW SUPPORT ASSEMBLY TM-109, EXCEPT TIE ANGLE IS	
		3½" x 3" x 1/4" x 15'- 0"	
5	4	GAIN PLATE, HUGHES 1004	
6	2	SPRING WASHER	aw
7	2	7/8" x REQUIRED LENGTH, THREADED ROD	
8	3	SPACER FITTING ASSEMBLY, SEPARATION AS REQUIRED	
9	4	LOCKNUTS FOR 7/8" BOLTS	ek
10	AS REQ.	NO. 6 COPPERWELD	cj
11	1	COMPRESSION CONNECTOR FOR GROUNDWIRE	
12	3	SUSPENSION HOOK	eh
13	3	SUSPENSION CLAMP AND CONNECTING PIECE	ei
14	1	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
15	2	OHGW SUSPENSION CLAMP	m
16	2	5/8" x REQUIRED LENGTH MACHINE BOLT	c
17	2	CURVED WASHER, 11/16" HOLE, 4" x 4" SQ. HUGHES CW-60	
18	2	LOCKNUT FOR 5/8" BOLT	ek
19	1	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
20	1	X-BRACE ASSEMBLY, TM-110	
21	1	NUT - 5/8", HUGHES N60	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TS-1X TO TH-1AAXM
(69KV TO 138KV)

DATE: 12-80 | FIG. 123



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. WOOD POLE GAINING AND GAIN PLATES MAY BE ELIMINATED WITH THE INSTALLATION OF GRID GAINS (BETHEA/NATIONAL CAG-54-7) WHEN SPECIFIED BY THE ENGINEER.
3. THE "NEW" POLE MAY BE MATCHED IN HEIGHT WITH THE EXISTING POLE AND INSTALL TWO BAYONET EXTENSION ASSEMBLIES WHEN SPECIFIED BY THE ENGINEER.
4. CROSSBRACES MAT BE INSTALLED WHEN SPECIFIED BY THE ENGINEER.

CONVERSION STRUCTURE TS-1X TO TH-10M (69KV TO 161KV)		
DATE: 12-80	FIG. 124	

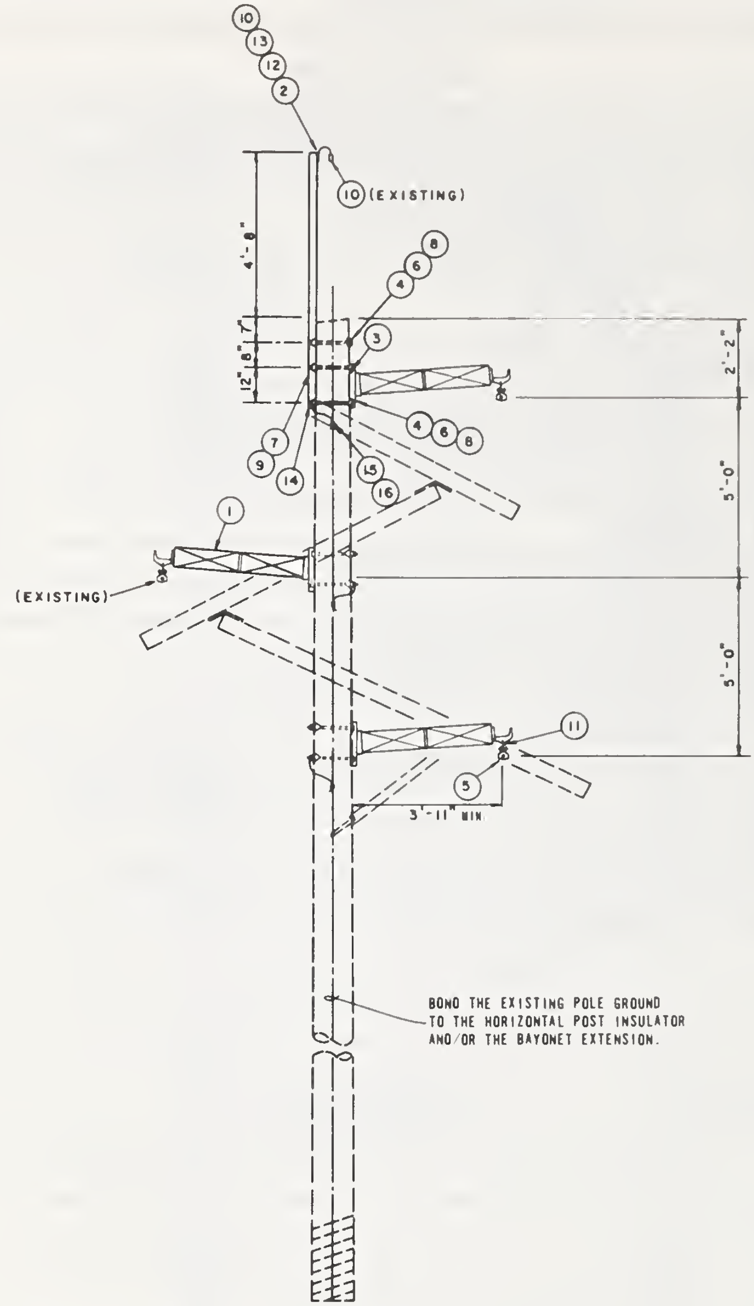
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	2	3 5/8" x 9 3/8" x 32'- 0" WOOD CROSSARM, TYPE 71	g
2	4	RIBBED TIE PLATE, HUGHES 1005	
3	AS REQ.	5 3/4" 10" SUSPENSION INSULATOR	k
4	1	OHGW SUPPORT ASSEMBLY TM-109, TIE ANGLE IS	
		3½" x 3" x 1/4" x 18'- 0"	
5	4	GAIN PLATE, HUGHES 1004	
6	2	SPRING WASHER	aw
7	2	7/8" x REQUIRED LENGTH, THREADED ROD	
8	3	SPACER FITTING ASSEMBLY, SEPARATION, AS REQUIRED	
9	4	LOCKNUTS FOR 7/8" BOLTS	ek
10	AS REQ.	NO. 6 COPPERWELD	cj
11	1	COMPRESSION CONNECTOR FOR GROUNDWIRE	
12	3	SUSPENSION HOOK	eh
13	3	SUSPENSION CLAMP AND CONNECTING PIECE	ei
14	1	BONDING CLIP FOR 5/8", BOLT HUGHES 2727.6	
15	2	OHGW SUSPENSION CLAMP	m
16	2	5/8" x REQUIRED LENGTH MACHINE BOLT	c
17	2	CURVED WASHER, 11/16" HOLE, 4" x 4" SQ. HUGHES CW-60	
18	2	LOCKNUT FOR 5/8" BOLT	ek
19	1	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
20	1	NUT 5/8", HUGHES N60	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TS-1X TO TH-10M
(69KV TO 161KV)

DATE:12-80 | FIG. 125



NOTES:

1. THE GROUND CLEARANCE MAY BE INCREASED BY MOUNTING THE CONDUCTOR IN A HORIZONTAL POST CLAMP POSITION.
2. THE ENGINEER MAY RELOCATE THE ATTACHMENT POINT OF THE HORIZONTAL POST INSULATORS.
3. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.

CONVERSION STRUCTURE
TSZ-1 TO TSZ-1-HP
(69KV TO 115KV)

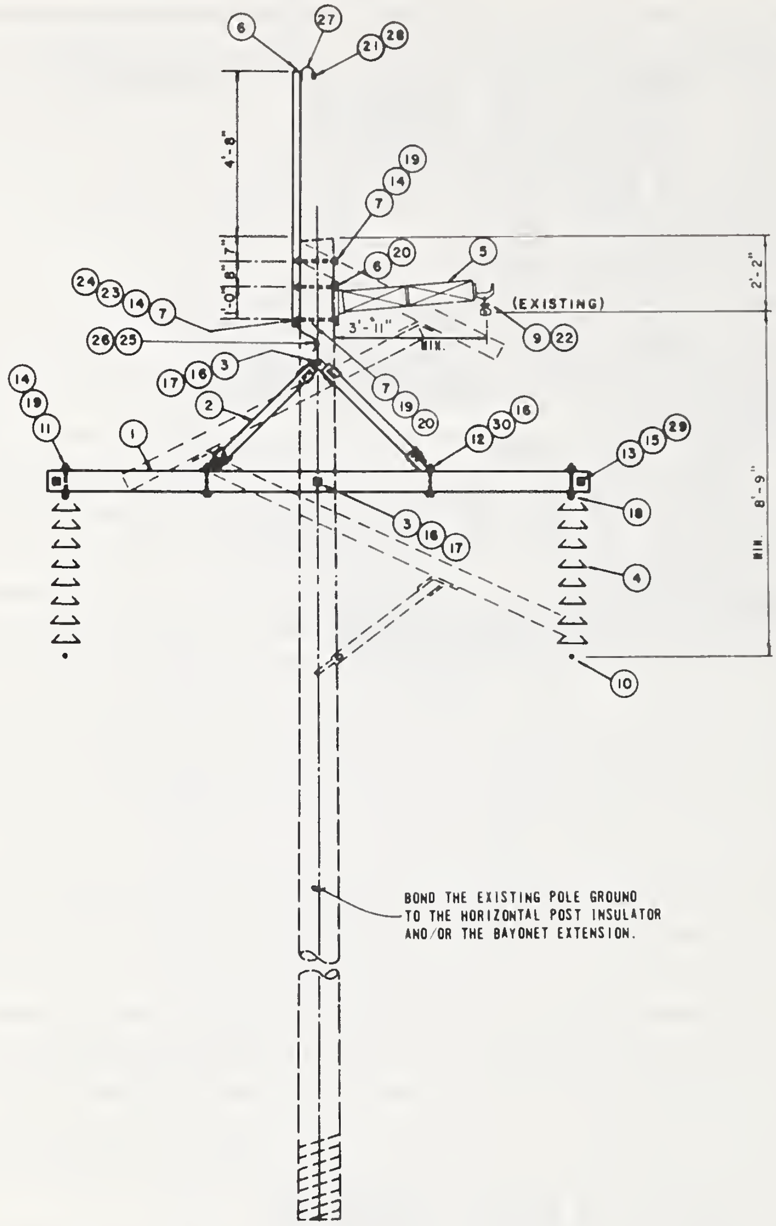
DATE: 12-80	FIG. 126	

LIST OF MATERIALS			
DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	3	HORIZONTAL POST INSULATOR, 115KV	ea
2	1	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
3	3	3/4" x REQUIRED LENGTH, MACHINE BOLT	c
4	4	5/8" x REQUIRED LENGTH, MACHINE BOLT	c
5	3	SUSPENSION CLAMP (AGS UNIT OPTIONAL)	ei
6	4	LOCKNUT FOR 5/8" BOLT	ek
7	3	LOCKNUT FOR 3/4" BOLT	ek
8	3	CURVED WASHER, 11/16" HOLE 3" x 3" x 5/16"	d
9	2	CURVED WASHER, 13/16" HOLE 4" x 4" x 1/2"	d
10	1	OHGW SUSPENSION CLAMP (AGS UNIT OPTIONAL)	
11	3	ANCHOR SHACKLE	bo
12	1	GOOSENECK, JOSLIN J2529	
13	1	Y-CLEVIS EYE FOR OHGW CLAMP, LAPP 7858	
14	3	BONDING CLIP FOR 5/8" BOLT HUGHES 2727.6	
15	AS REQ.	NO. 6 COPPERWELD	cj
16	3	COMPRESSION CONNECTOR FOR GROUNDWIRE	
17	3	NUT - 5/8", HUGHES N60	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TSZ-1 TO TSZ-1-HP
(69KV TO 115KV)

DATE:12-00 | FIG. 127



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. ADDITIONAL GROUND CLEARANCE MAY BE OBTAINED BY MOUNTING THE CONDUCTOR IN A HORIZONTAL POST CLAMP POSITION.

CONVERSION STRUCTURE TSZ-1 TO TSZ-MPH (69KV TO 115 KV)		
DATE: 12-80	FIG. 128	

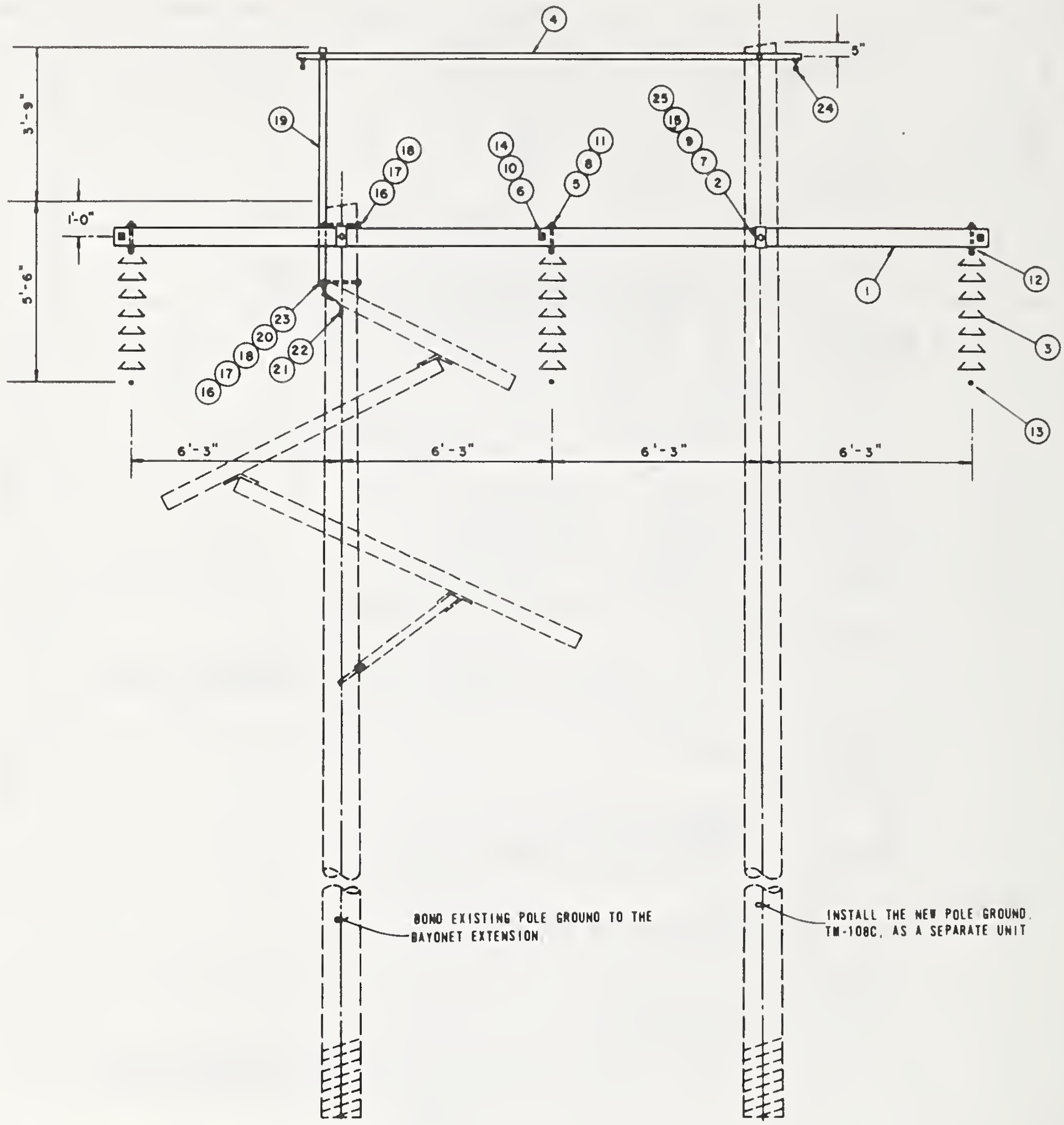
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	1	5 5/8" x 7 3/8" x 15' WOOO CROSSARM	g
2	1	72" WOOD CROSSARM BRACE, HUGHES #2018	
3	2	7/8" x REQUIREO LENGTH, MACHINE 8OLT	c
4	AS REQ.	5 3/4" x 10" SUSPENSION INSULATOR	k
5	1	HORIZONTAL POST INSULATOR, 115KV	ea
6	1	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
7	2	5/8" x REQUIREO LENGTH, MACHINE BOLT	c
8	1	3/4" x REQUIRED LENGTH, MACHINE BOLT	c
9	1	SUSPENSION CLAMP (AGS UNIT OPTIONAL)	
10	2	SUSPENSION CLAMP ANO CONNECTING PIECE	ei
11	2	5/8" x 9" EYEBOLT	o
12	2	7/8" x 9" MACHINE BOLT	c
13	2	LOCKNUT FOR 1/2" BOLT	ek
14	4	LOCKNUT FOR 5/8" BOLT	ek
15	2	1 3/8" GALV. ROUNO WASHER, 9/16" HOLE	d
16	4	LOCKNUT FOR 7/8" BOLT	ek
17	2	3" x 4" x 7/16" GALV. WASHER, 15/16" HOLE	d
18	2	SUSPENSION HOOK	eh
19	2	3" x 3" x 3/16", GALV. SQ. WASHER, 11/16" HOLE HUGHES SW3-60	
20	1	LOCKNUT FOR 3/4" BOLT	
21	1	SHIELO WIRE CLAMP	m
22	1	ANCHOR SHACKLE	bo
23	1	NUT - 5/8" HUGHES N60	
24	1	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
25	AS REQ.	NO. 6 COPPERWELD	cj
26	1	COMPRESSION CONNECTOR FOR GROUNDWIRE	
27	1	GOOSENECK, JOSLIN J2529	
28	1	Y-CLEVIS EYE FOR OHGW CLAMP, LAPP 7858	
29	2	1/2" x 7" MACHINE BOLT	c
30	2	3" x 3" x 3/16" GALV. SQ. WASHER 15/16" HOLE, HUGHES SW3-80	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY COOE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. ANO CATALOG NO. ARE SPECIFIEO TO IOENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USEO.

CONVERSION STRUCTURE
TSZ-1 TO TSZ-MPH
(69KV TO 115KV)

OATE: 12-80 | FIG. 129



NOTES:

1. THE BAYONET EXTENSION, JOSLIN J1134, MAY BE MOUNTED TO EITHER THE FACE OR THE SIDE OF THE POLE AS DETERMINED BY THE ENGINEER.
2. WOOD POLE GAINING AND GAIN PLATES MAY BE ELIMINATED WITH THE INSTALLATION OF GRID GAINS (BETHEA/NATIONAL CAG-54-7) WHEN SPECIFIED BY THE ENGINEER.
3. THE "NEW" POLE MAY BE MATCHED IN HEIGHT WITH THE EXISTING POLE AND INSTALL TWO BAYONET EXTENSION ASSEMBLIES WHEN SPECIFIED BY THE ENGINEER.
4. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
5. THE USE OF CROSSBRACES MUST BE ECONOMICALLY JUSTIFIED.

CONVERSION STRUCTURE TSZ-1 TO TH-1A (MOD.) (69KV TO 115KV)		
DATE: 12 - 80	FIG. 130	

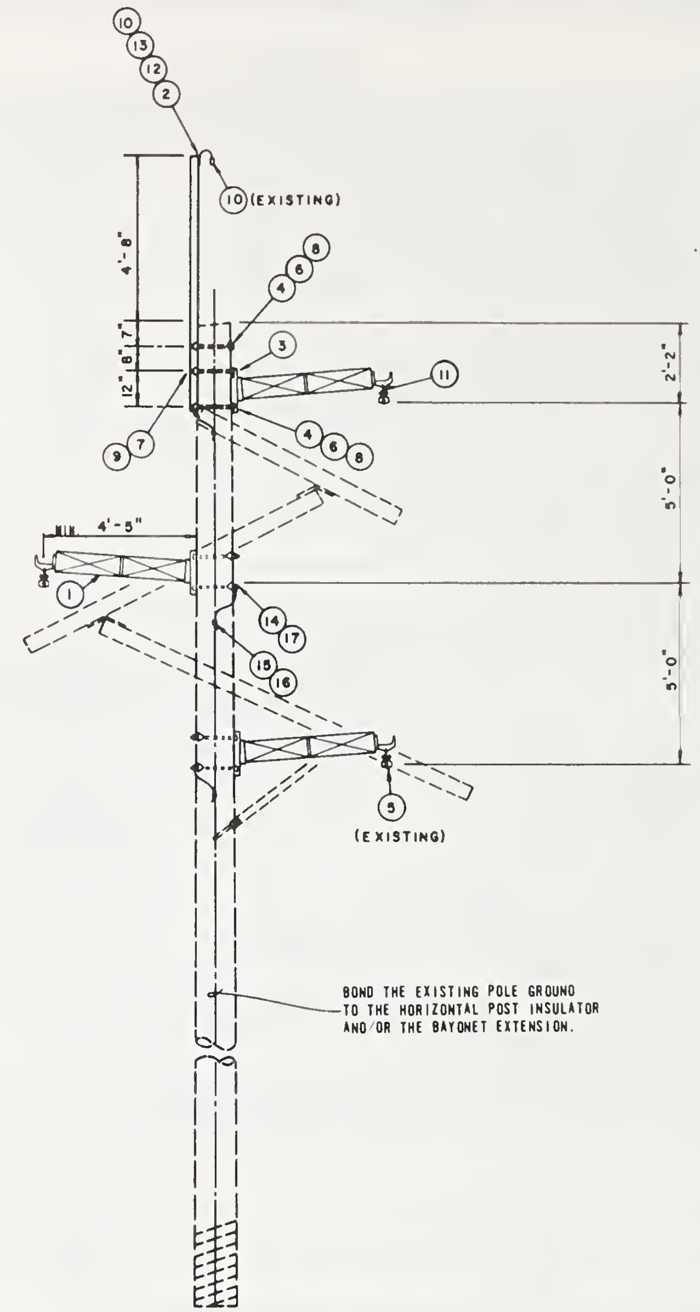
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	1	5 3/8" x 7 5/8" x 26'- 0" WOOD CROSSARM, TYPE 55	g
2	2	RIBBED TIE PLATE, HUGHES 1005	
3	AS REQ.	5 3/4" x 10" SUSPENSION INSULATOR	k
4	1	OHGW SUPPORT ASSEMBLY TM-109, EXCEPT TIE ANGLE IS	
		3 ½" x 3" x 1/4" x 15'- 0"	
5	3	3/4" x 10" EYE BOLT	o
6	3	1/2" x 8" MACHINE BOLT	c
7	2	7/8" x REQUIRED LENGTH, MACHINE BOLT	c
8	3	4" x 4" x 3/16" GALV. SQ. WASHER, 13/16" HOLE	d
9	2	LOCKNUTS FOR 7/8" BOLTS	ek
10	3	LOCKNUTS FOR 1/2" BOLTS	ek
11	3	LOCKNUTS FOR 3/4" BOLTS	ek
12	3	SUSPENSION HOOK	eh
13	3	SUSPENSION CLAMP AND CONNECTING PIECE	ei
14	3	2¼" x 2¼" GALV. SQ. WASHER, 9/16" HOLE HUGHES SW 2¼-50	
15	2	4" x 4" x 1/4" SQ. CURVED WASHER, 15/16" HOLE, HUGHES CW-80	
16	2	5/8" x REQUIRED LENGTH MACHINE BOLT	c
17	2	CURVED WASHER, 11/16" HOLE 4" x 4" SQ. HUGHES SW4-60	
18	2	LOCKNUT FOR 5/8" BOLT	ek
19	1	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
20	1	NUT - 5/8" HUGHES N60	
21	1	COMPRESSION CONNECTOR FOR GROUNDWIRE	
22	AS REQ.	NO. 6 COPPERWELD	cj
23	1	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
24	2	OHGW SUSPENSION CLAMP	m
25	2	GAIN PLATE, HUGHES 1004	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TSZ-1 TO TH-1A (MOD.)
(69KV TO 115KV)

DATE:12-80 | FIG. 131



NOTES:

1. THE GROUND CLEARANCE MAY BE INCREASED BY MOUNTING THE CONDUCTOR IN A HORIZONTAL POST CLAMP POSITION.
2. THE ENGINEER MAY RELOCATE THE ATTACHMENT POINT OF THE HORIZONTAL POST INSULATORS.
3. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.

CONVERSION STRUCTURE
TSZ-1 TO TSZ-1-HP
(69KV TO 138KV)

DATE 12-80	FIG. 132	

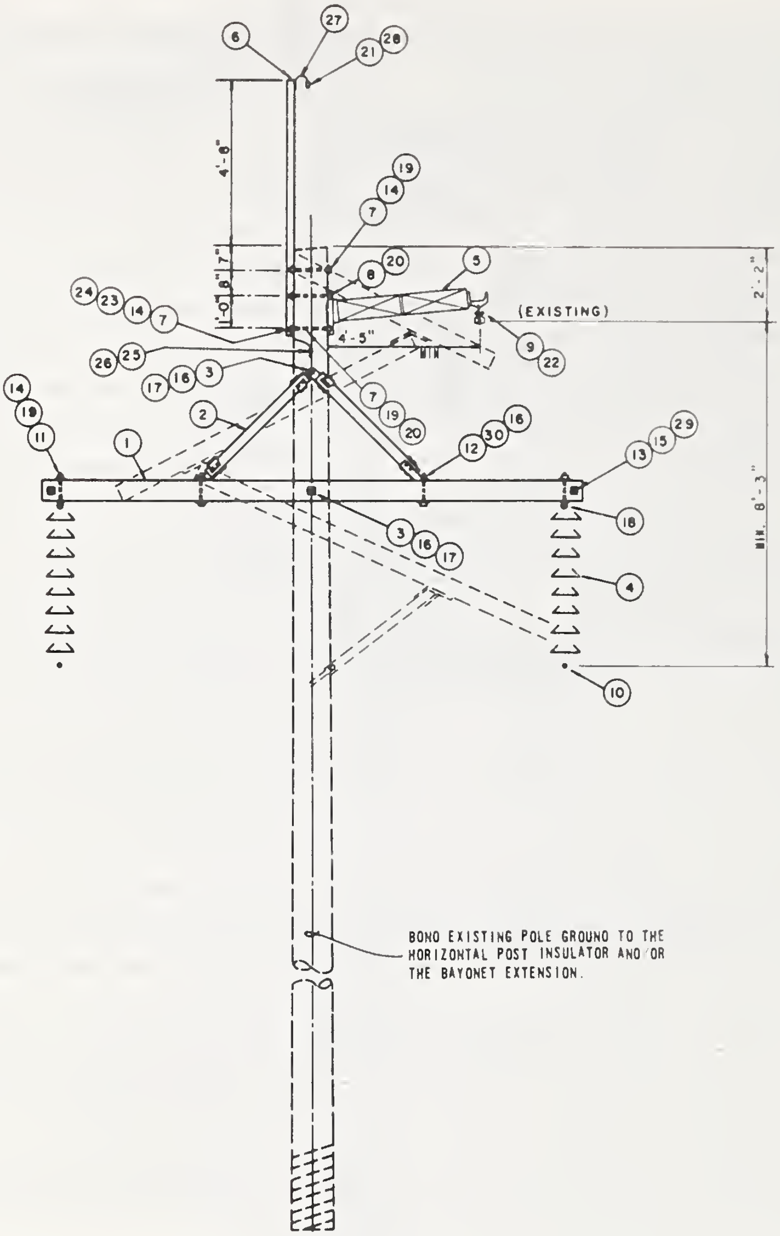
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	3	HORIZONTAL POST INSULATOR, 138KV LAPP 70148	
2	1	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
3	3	3/4" x REQUIREO LENGTH, MACHINE BOLT	c
4	4	5/8" x REQUIRED LENGTH, MACHINE BOLT	c
5	3	SUSPENSION CLAMP (AGS UNIT OPTIONAL)	ei
6	4	LOCKNUT FOR 5/8" BOLT	ek
7	3	LOCKNUT FOR 3/4" BOLT	ek
8	3	CURVED WASHER, 11/16" HOLE	d
9	2	CURVED WASHER, 13/16" HOLE	d
10	1	OHGW SUSPENSION CLAMP (AGS UNIT OPTIONAL)	
11	3	ANCHOR SHACKLE	bo
12	1	GOOSENECK, JOSLIN J2529	
13	1	Y-CLEVIS EYE FOR OHGW CLAMP, LAPP 7858	
14	3	BONDING CLIP FOR 5/8" BOLT HUGHES 2727.6	
15	AS REQ.	NO. 6 COPPERWELD	cj
16	3	COMPRESSION CONNECTOR FOR GROUNDWIRE	
17	3	NUT 5/8" HUGHES N 60	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY COOE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIEO TO IOENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USEO.

CONVERSION STRUCTURE
TSZ-1 TO TSZ-1-HP
(69KV TO 138KV)

DATE: 12-80 | FIG. 133



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. ADDITIONAL GROUND CLEARANCE MAY BE OBTAINED BY MOUNTING THE CONDUCTOR IN A HORIZONTAL POST CLAMP POSITION.

CONVERSION STRUCTURE
TSZ-1 TO TSZ-MPH
(69KV TO 138KV)

DATE: 12-80

FIG. 134

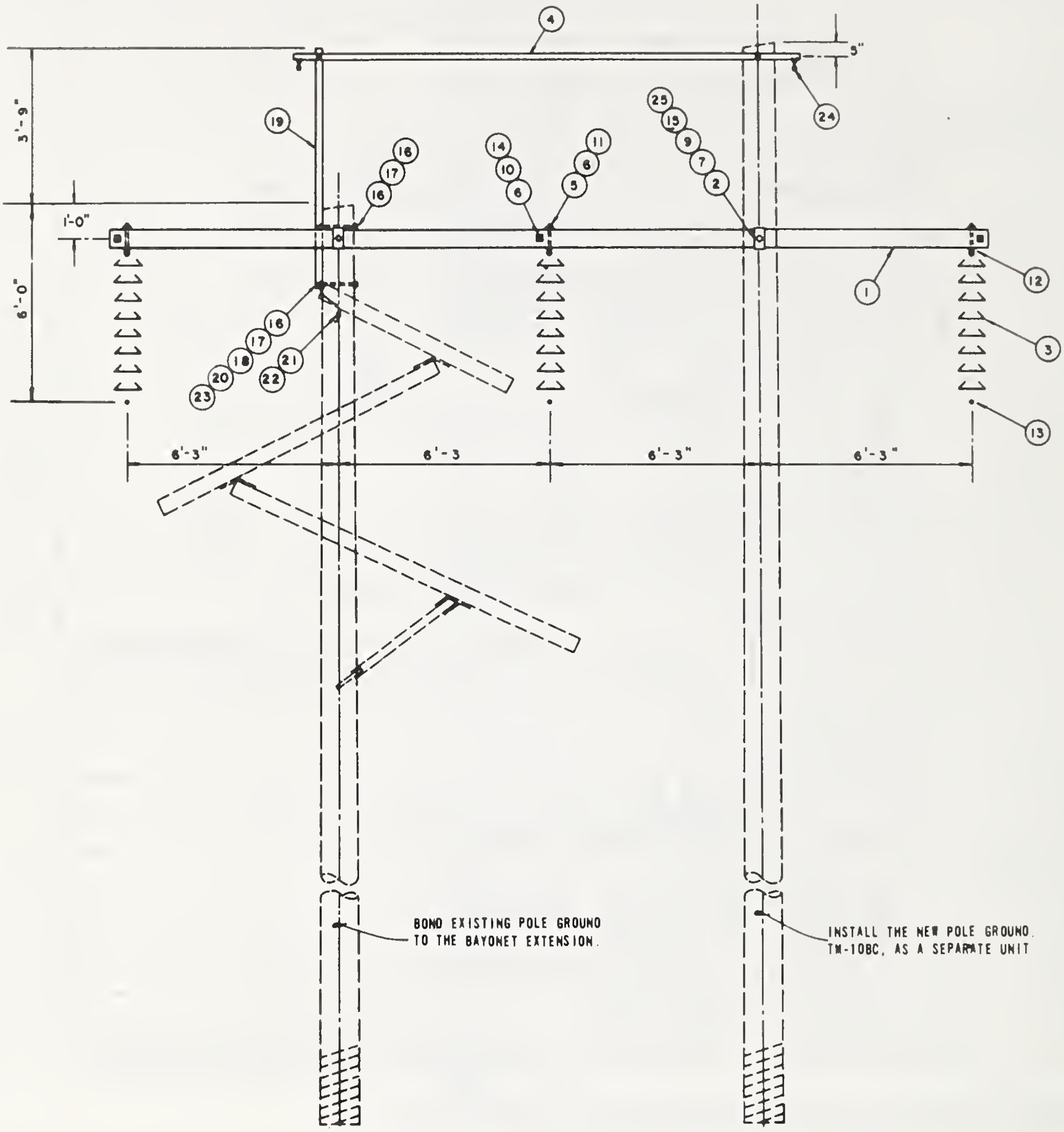
LIST OF MATERIALS			
DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	1	5-5/8" x 7-3/8" x 15' WOOD CROSSARM	g
2	1	72" WOOD CROSSARM BRACE, HUGHES #2018	
3	2	7/8" x REQUIRED LENGTH, MACHINE BOLT	c
4	AS REQ.	5 3/4" x 10" SUSPENSION INSUUATOR	k
5	1	HORIZONTAL POST INSULATOR, 138KV LAPP 70148	
6	1	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
7	2	5/8" x REQUIRED LENGTH, MACHINE BOLT	c
8	1	3/4" x REQUIRED LENGTH, MACHINE BOLT	c
9	1	SUSPENSION CLAMP (AGS UNIT OPTIONAL)	
10	2	SUSPENSION CLAMP AND CONNECTING PIECE	ei
11	2	5/8" x 9" EYEBOLT	o
12	2	7/8" x 9" MACHINE BOLT	c
13	2	LOCKNUT FOR 1/2" 8OLT	ek
14	4	LOCKNUT FOR 5/8" 8OLT	ek
15	2	1 3/8" GALV. ROUND WASHER, 9 /16" HOLE	d
16	4	LOCKNUT FOR 7/8" BOLT	ek
17	2	3" x 4" x 7/16" GALV. WASHER, 15/16" HOLE	d
18	2	SUSPENSION HOOK	eh
19	2	3" x 3" x 3/16" GALV. SQ. WASHER, 11/16" HOLE ,HUGHES SW3-60	
20	1	LOCKNUT FOR 3/4" 8OLT	
21	1	SHIELD WIRE CLAMP	m
22	1	ANCHOR SHACKLE	bo
23	1	NUT - 5/8" HUGHES N60	
24	1	8ONDING CLIP FOR 5/8" 8OLT, HUGHES 2727.6	
25	AS REQ.	NO. 6 COPPERWELD	cj
26	1	COMPRESSION CONNECTOR FOR GROUNDWIRE	
27	1	GOOSENECK, JOSLIN J2529	
28	1	Y-CLEVIS EYE FOR OHGW CLAMP, LAPP 7858	
29	2	1/2" x 7" MACHINE BOLT	c
30	2	3" x 3" x 3/16" GALV. SQ. WASHER 15/16" HOLE, HUGHES SW3-80	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TSZ-1 TO TSZ-MPH
(69KV TO 138KV)

DATE:12-80

FIG. 135



NOTES:

1. THE BAYONET EXTENSION, JOSLIN J1134, MAY BE MOUNTED TO EITHER THE FACE OR THE SIDE OF THE POLE AS DETERMINED BY THE ENGINEER.
2. WOOD POLE GAINING AND GAIN PLATES MAY BE ELIMINATED WITH THE INSTALLATION OF GRID GAINS (BETHEA/NATIONAL CAG-54-7) WHEN SPECIFIED BY THE ENGINEER.
3. THE "NEW" POLE MAY BE MATCHED IN HEIGHT WITH THE EXISTING POLE AND INSTALL TWO BAYONET EXTENSION ASSEMBLIES WHEN SPECIFIED BY THE ENGINEER.
4. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.

CONVERSION STRUCTURE
TSZ-1 TO TH-1A (MOD.)
(69KV TO 138KV)

DATE: 12-80	FIG. 136	

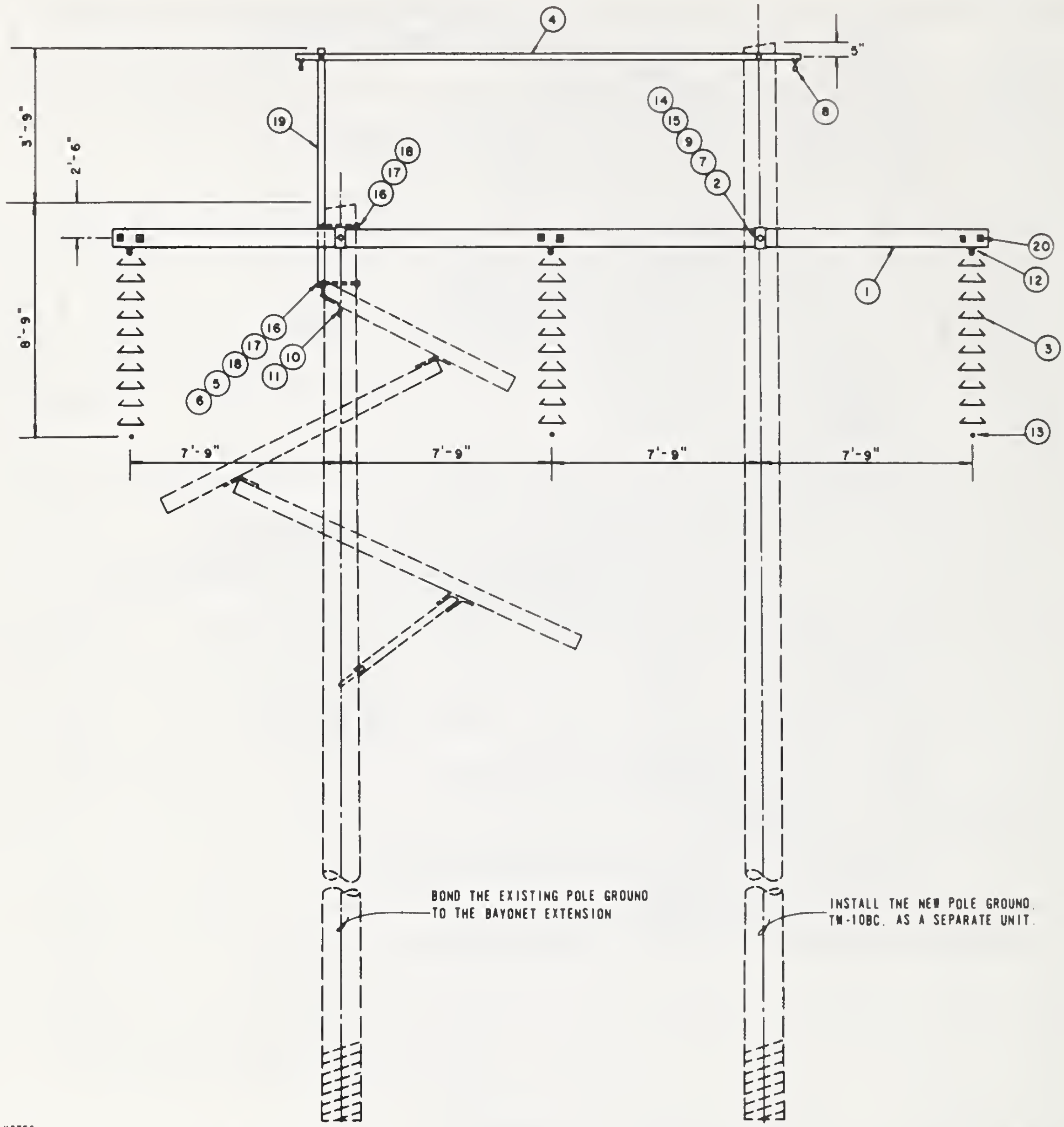
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	1	5 3/8" x 7 5/8" x 26'- 0" WOOO CROSSARM, TYPE 55	g
2	2	RIBBED TIE PLATE, HUGHES 1005	
3	AS REQ.	5 3/4" x 10" SUSPENSION INSULATOR	k
4	1	OHGW SUPPORT ASSEMBLY TM-109, EXCEPT TIE ANGLE IS	
		3½" x 3" x 1/4" x 15'- 0"	
5	3	1/2" x 8" MACHINE BOLT	c
6	3	1/2" x 8" MACHINE BOLT	c
7	2	7/8" x REQUIRED LENGTH, MACHINE BOLT	c
8	3	4" x 4" x 3/16" GALV. SQ. WASHER, 13/16" HOLE	d
9	2	LOCKNUTS FOR 7/8" BOLTS	ek
10	3	LOCKNUTS FOR 1/2" BOLTS	ek
11	3	LOCKNUTS FOR 3/4" BOLTS	ek
12	3	SUSPENSION HOOK	eh
13	3	SUSPENSION CLAMP AND CONNECTING PIECE	ei
14	3	2¼" x 2¼" GALV. SQ. WASHER, 9/16" HOLE HUGHES SW2¼-50	
15	2	4" x 4" x 1/4" SQ. CURVED WASHER, 15/16" HOLE HUGHES CW-80	
16	2	5/8" x REQUIRED LENGTH MACHINE BOLT	c
17	2	CURVEO WASHER, 11/16" HOLE, 4" x 4" SQ. HUGHES SW4-60	
18	2	LOCKNUT FOR 5/8" BOLT	ek
19	1	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
20	1	NUT - 5/8" HUGHES N60	
21	1	COMPRESSION CONNECTOR FOR GROUNOWIRE	
22	AS REQ.	NO. 6 COPPERWELO	cj
23	1	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
24	2	OHGW SUSPENSION CLAMP	m
25	2	GAIN PLATE, HUGHES 1004	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. ANO CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TSZ-1 TO TH-1A (MOO.)
(69KV TO 138KV)

DATE: 12-80 | FIG. 137



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. WOOD POLE GAINING AND GAIN PLATES MAY BE ELIMINATED WITH THE INSTALLATION OF GRID GAINS (BETHEA/NATIONAL CAG-54-7) WHEN SPECIFIED BY THE ENGINEER.
3. THE "NEW" POLE MAY BE MATCHED IN HEIGHT WITH THE EXISTING POLE AND INSTALL TWO BAYONET EXTENSION ASSEMBLIES WHEN SPECIFIED BY THE ENGINEER.
4. CROSSBRACES MAY BE INSTALLED WHEN SPECIFIED BY THE ENGINEER.

CONVERSION STRUCTURE TSZ-1 TO TH-10K (69KV TO 161KV)		
DATE: 12-80	FIG. 138	

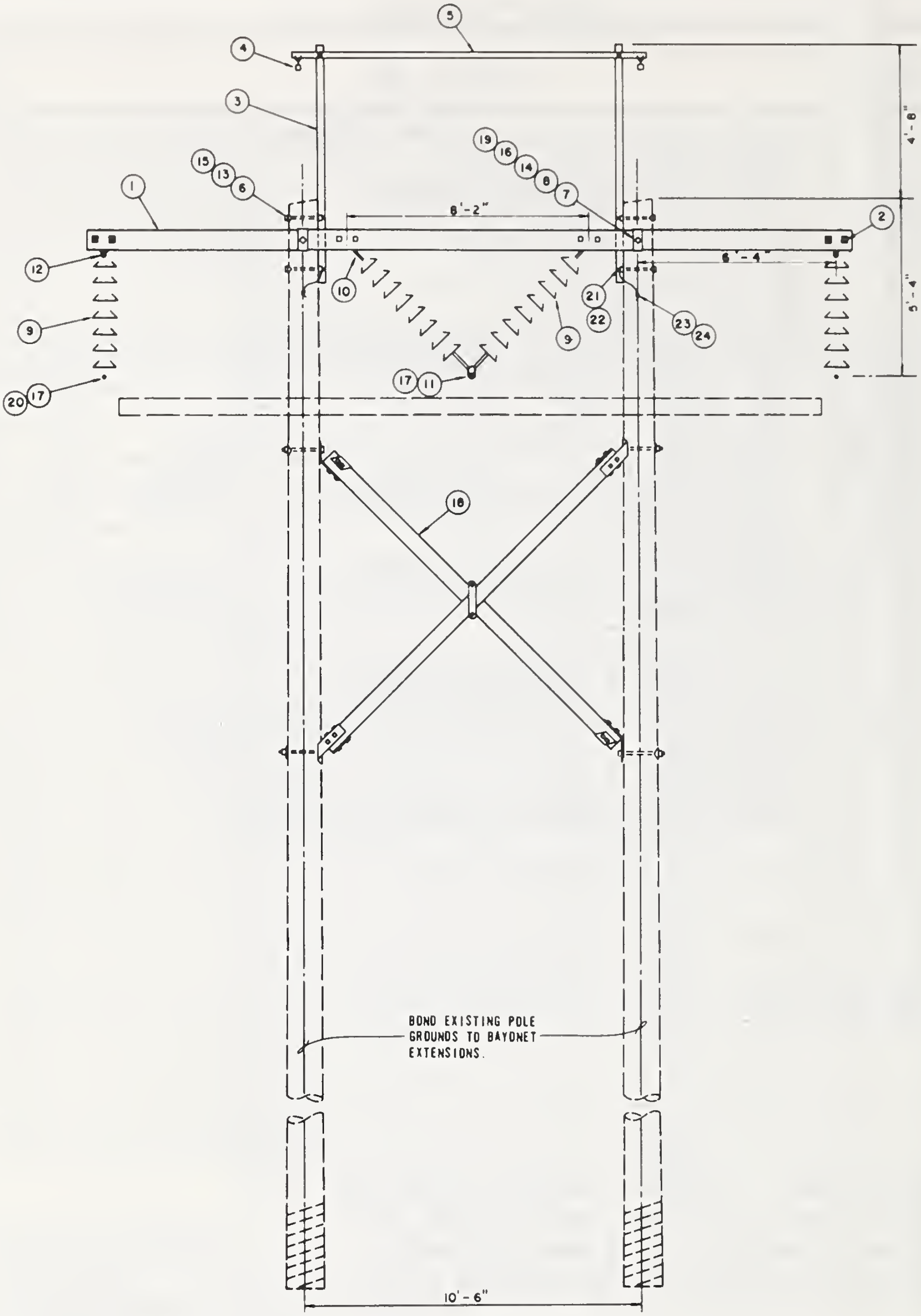
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	2	3 5/8" x 9 3/B" x 32'- 0" WOOO CROSSARM, TYPE 71	g
2	4	RIBBED TIE PLATE, HUGHES 1005	
3	AS REQ	5 3/4" x 10" SUSPENSION INSULATOR	k
4	1	OHGW SUPPORT ASSEMBLY TM-109, TIE ANGLE IS	
		3½" x 3" x 1/4" x 18'- 0"	
5	1	NUT - 5/8", HUGHES N60	
6	1	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
7	2	7/B" x REQUIRED LENGTH, THREAOED ROO	
8	2	OHGW SUSPENSION CLAMP	m
9	4	LOCKNUTS FOR 7/8" 8OLTS	ek
10	AS REQ.	NO. 6 COPPERWELD	cj
11	1	COMPRESSION CONNECTOR FOR GROUNDWIRE	
12	3	SUSPENSION HOOK	eh
13	3	SUSPENSION CLAMP ANO CONNECTING PIECE	ei
14	2	SPRING WASHER	aw
15	4	GAIN PLATE, HUGHES 1004	
16	2	5/8" x REQUIREO LENGTH MACHINE 8OLT	c
17	2	CURVED WASHER, 11/16" HOLE 4" x 4" SQ. HUGHES SW4-60	
18	2	LOCKNUT FOR 5/8" 8OLT	ek
19	1	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
20	3	SPACER FITTING ASSEMBLY, SEPARATION AS REQUIREO	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY COOE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. ANO CATALOG NO. ARE SPECIFIEO TO IOENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTEO MAY 8E USEO.

CONVERSION STRUCTURE
TSZ-1 TO TH-10K
(69KV TO 161KV)

DATE: 12-80 | FIG. 139



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. WOOD POLE GAINING AND GAIN PLATES MAY BE ELIMINATED WITH THE INSTALLATION OF GRID GAINS (BETHEA/NATIONAL CAG-54-7) WHEN SPECIFIED BY THE ENGINEER.
3. THE LOCATION AND QUANTITY OF CROSSBRACES IS TO BE DETERMINED BY THE ENGINEER.

CONVERSION STRUCTURE
TH-1G TO TH-VS
(69KV TO 115KV)

DATE 12-80	FIG. 140	

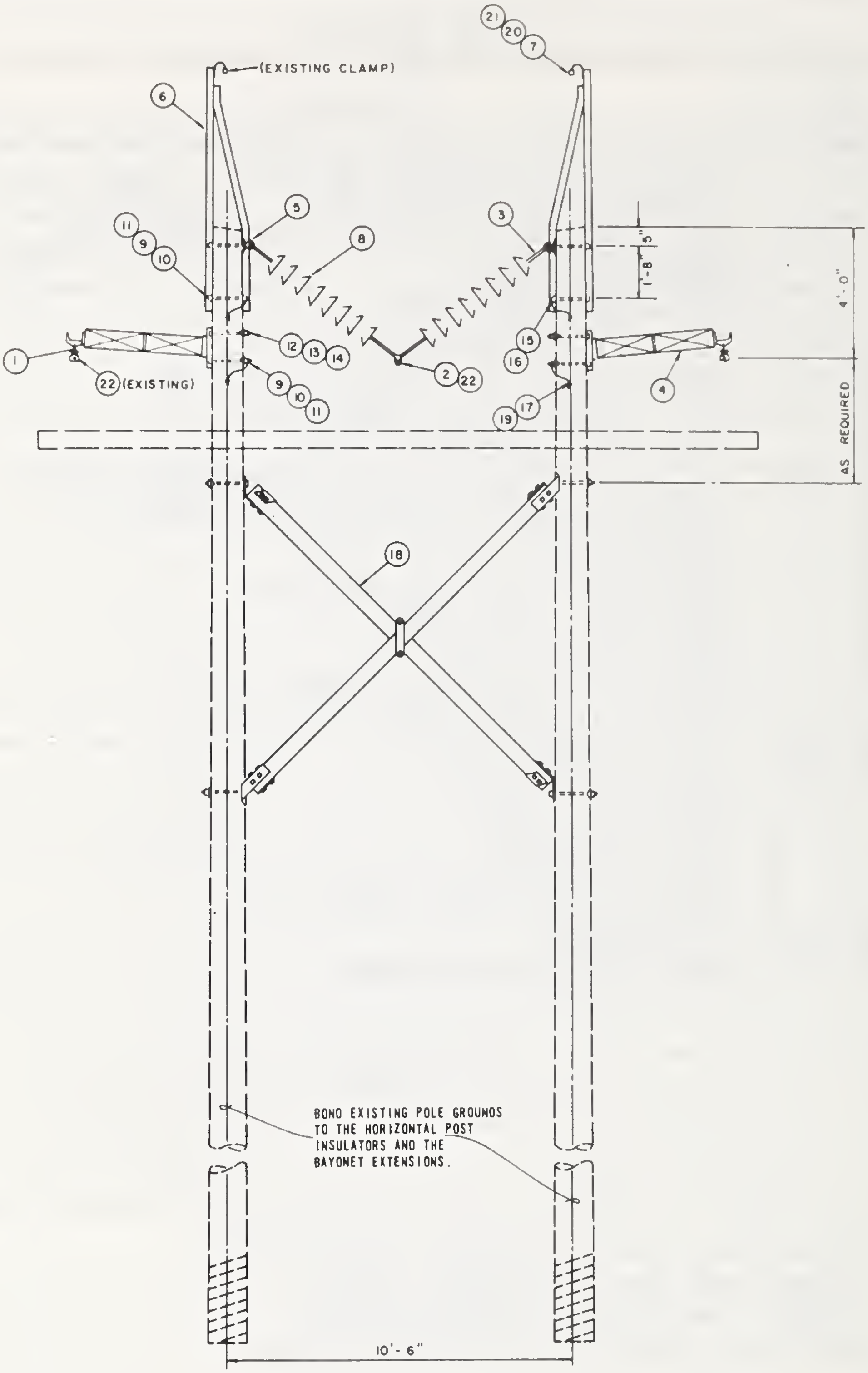
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	2	3 5/8" x 7½" x 24'-0" WOOD CROSSARM	g
2	4	ADJUSTABLE SPACERS HUGHES NO. 3400	
3	2	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
4	2	OHGW SUSPENSION CLAMP	m
5	1	OHGW SUPPORT ASSEMBLY TM-109	
6	4	5/8" x REQUIRED LENGTH MACHINE BOLT	c
7	4	RIBBED TIE PLATE, 3" x 7½" x 1/4", HUGHES 1005	
8	2	7/8" x REQUIRED LENGTH, THREADED ROD	
9		5 3/4" x 10" SUSPENSION INSULATOR	k
10	2	BALL CLEVIS, HOT LINE, "Y" TYPE, BETHEA/NATIONAL YCBHL-65	
11	1	VEE STRING, SOCKET EYE ASSEMBLY, BETHEA/NATIONAL VSE-____	
12	2	SUSPENSION HOOK	eh
13	4	CURVED WASHER, 11/16" HOLE HUGHES SW4-60	
14	2	SPRING WASHER, 15/16" HOLE	aw
15	4	LOCKNUT FOR 5/8" BOLT	ek
16	4	GAIN PLATE, 3" x 7½" x 1/4" HUGHES 1004	
17	3	CONDUCTOR SUSPENSION CLAMP	
18	AS REQ'D.	X-BRACE ASSEMBLY, TM-110	
19	4	LOCKNUT FOR 7/8" BOLT	ek
20	2	SOCKET EYE ULT. 30,000#	
21	2	NUT 5/8" HUGHES N60	
22	2	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
23	AS REQ'D.	NO. 6 COPPERWELD	cj
24	2	COMPRESSION CONNECTOR FOR GROUNDWIRE	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TH-1G TO TH-VS
(69KV TO 115KV)

DATE: 12-80 | FIG. 141



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. ADDITIONAL GROUND CLEARANCE MAY BE OBTAINED BY MOUNTING THE CONDUCTOR IN A HORIZONTAL POST CLAMP POSITION.
3. THE EXISTING CROSSARM(S) CAN BE LEFT IN PLACE TO MAKE THE STRUCTURE MORE RIGID IF THE PORTION UNDER EACH HORIZONTAL POST INSULATOR IS REMOVED.

CONVERSION STRUCTURE TH-1G TO TH-HPX (69 KV TO 115 KV)		
DATE: 12-80	FIG. 142	

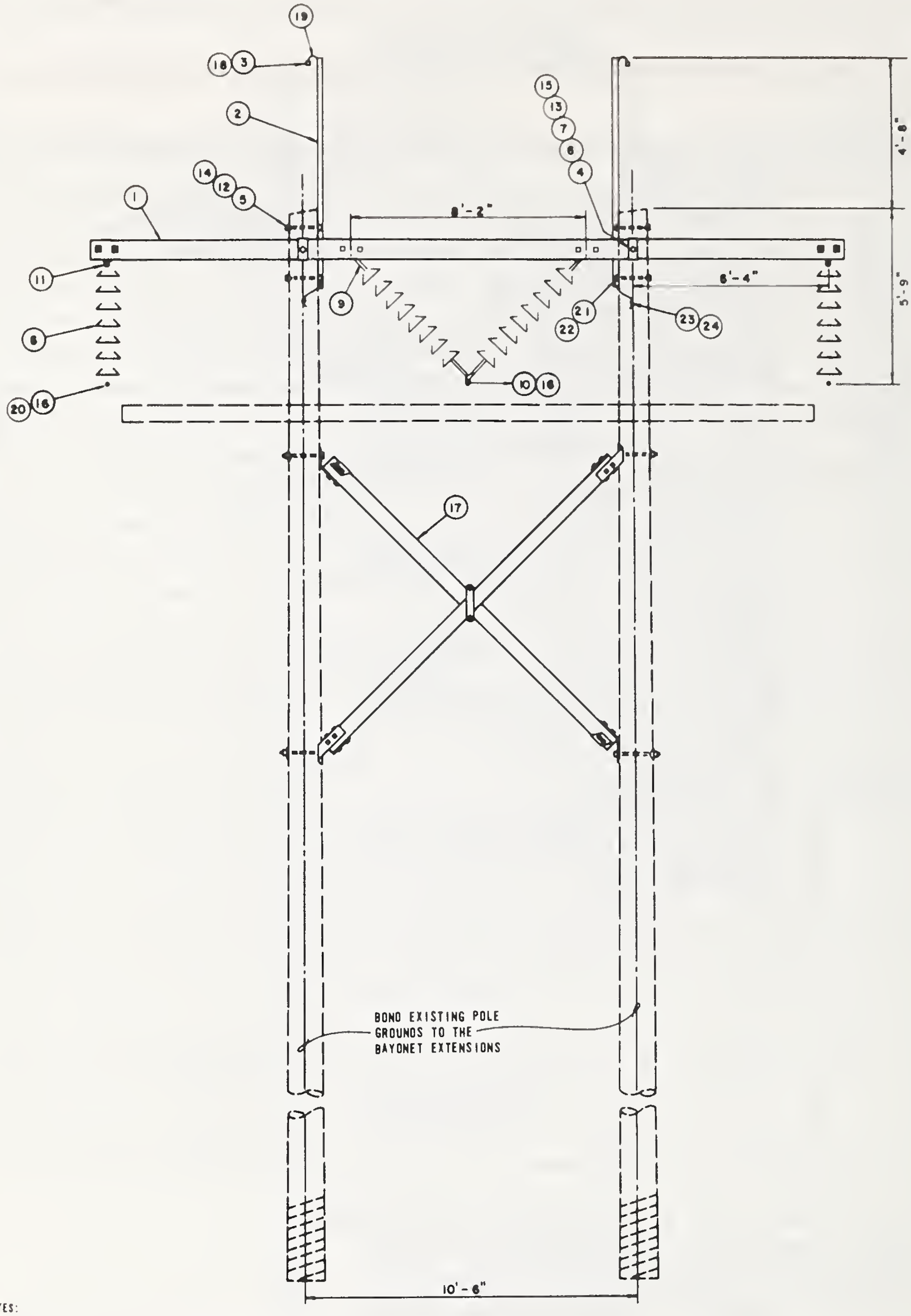
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	2	ANCHOR SHACKLE	bo
2	1	VEE STRING SOCKET EYE ASSEMBLY BETHEA/NATIONAL VSE- ----	
3	2	HOT LINE "Y" CLEVIS BALL BETHEA/NATIONAL YCBHL-65	
4	2	HORIZONTAL POST INSULATOR, 115KV	ea
5	2	EYELET, 5/8" JOSLIN J1126	
6	2	STEEL BAYONET, CORNER, 84", JOSLYN #J1139	
7	2	GOOSENECK BAYONET BRACKET JOSLIN J2529	
8	AS REQ.	5 3/4" x 10" SUSPENSION INSULATOR	k
9	6	5/8" x REQ'D. LENGTH MACHINE BOLT	c
10	2	CURVED WASHER, 11/16" HOLE, HUGHES SW4-60	
11	6	LOCKNUT FOR 5/8" BOLT	ek
12	2	3/4" x REQUIREO LENGTH MACHINE BOLT	c
13	2	CURVED WASHER, 13/16" HOLE, HUGHES SW4-70	
14	2	LOCKNUT FOR 3/4" BOLT	ek
15	4	BONDING CLIP FOR 5/8" BOLT HUGHES 2727.6	
16	4	NUT 5/8" HUGHES N60	
17	4	COMPRESSION CONNECTOR FOR GROUNOWIRE	
18	1	X-BRACE ASSEMBLY, TM-110	
19	AS REQ.	NO. 6 COPPERWELD	cj
20	2	OHGW SUSPENSION CLAMP	m
21	2	Y-CLEVIS EYE FOR OHGW CLAMP LAPP 7858	
22	2	SUSPENSION CLAMP	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY COOE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. ANO CATALOG NO. ARE SPECIFIEO TO IOENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USEO.

CONVERSION STRUCTURE
TH-1G TO TH-HPX
(69KV TO 115KV)

DATE:12-80 | FIG. 143



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. WOOD POLE GAINING AND GAIN PLATES MAY BE ELIMINATED WITH THE INSTALLATION OF GRID GAINS (BETHEA/NATIONAL CAG-54-7) WHEN SPECIFIED BY THE ENGINEER.
3. THE LOCATION AND QUANTITY OF CROSSBRACES IS TO BE DETERMINED BY THE ENGINEER.

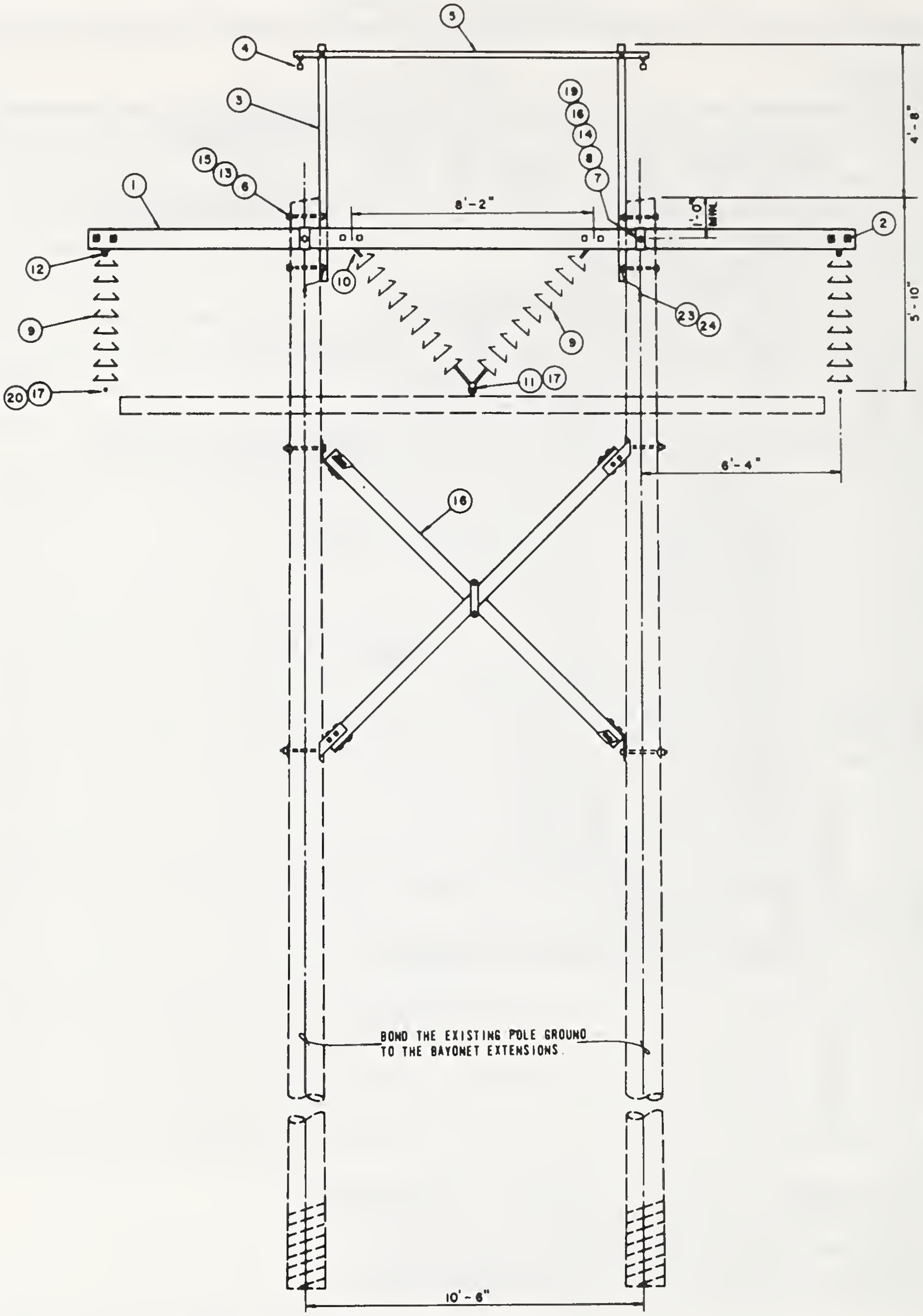
CONVERSION STRUCTURE TH-1G TO TH-24A (69KV TO 115KV)	
DATE: 12-80	FIG. 144

LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	2	3 5/8" x 7½" x 24'-0" WOOD CROSSARM ASSEMBLED WITH	g
		4-ADJUSTABLE SPACERS, HUGHES NO. 3400	
2	2	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
3	2	OHGW SUSPENSION UNIT	m
4	4	LOCKNUT FOR 7/8" BOLT	ek
5	4	5/B" x REQUIRED LENGTH MACHINE BOLT	c
6	4	RIBBED TIE PLATE, 3" x 7½" x 1/4" HUGHES 1005	
7	2	7/B" x REQUIREO LENGTH, THREADEO ROD	
B	AS REQ.	5 3/4" x 10" SUSPENSION INSULATOR	k
9	2	BALL CLEVIS, HOT LINE, "Y" TYPE, BETHEA/NATIONAL YCBHL-65	
10	1	VEE STRING, SOCKET EYE ASSY., BETHEA/NATIONAL VSE-	
11	2	SUSPENSION HOOK	eh
12	4	CURVEO WASHER, 11/16" HOLE, HUGHES SW4-60	
13	2	SPRING WASHER, 15/16" HOLE	aw
14	4	LOCKNUT FOR 5/B" BOLT	ek
15	4	GAIN PLATE, 3" x 7½" x 1/4" HUGHES 1004	
16	3	CONDUCTOR SUSPENSION CLAMP	
17	AS REQ'D.	X-BRACE ASSEMBLY, TM-110	
1B	2	Y-CLEVIS EYE FOR OHGW CLAMP, LAPP 785B	
19	2	GOOSENECK, JOSLIN J2529	
20	2	SOCKET EYE ULT. 30,000#	
21	2	NUT - 5/B" HUGHES N60	
22	2	BONDING CLIP FOR 5/8" BOLT HUGHES 2727.6	
23	AS REQ'D.	NO. 6 COPPERWELD	cj
24	2	COMPRESSION CONNECTOR FOR GROUNDWIRE	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. ANO CATALOG NO. ARE SPECIFIEO TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USEO.

CONVERSION STRUCTURE TH-1G TO TH-24A (69KV TO 115KV)		
DATE:12-80	FIG. 145	



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. WOOD POLE GAINING AND GAIN PLATES MAY BE ELIMINATED WITH THE INSTALLATION OF GRID GAINS (BETHEA/NATIONAL CAG-54-7) WHEN SPECIFIED BY THE ENGINEER.
3. THE LOCATION AND QUANTITY OF CROSSBRACES IS TO BE DETERMINED BY THE ENGINEER.

CONVERSION STRUCTURE TH-1G TO TH-VS (69KV TO 138KV)	
DATE: 12-80	FIG. 146

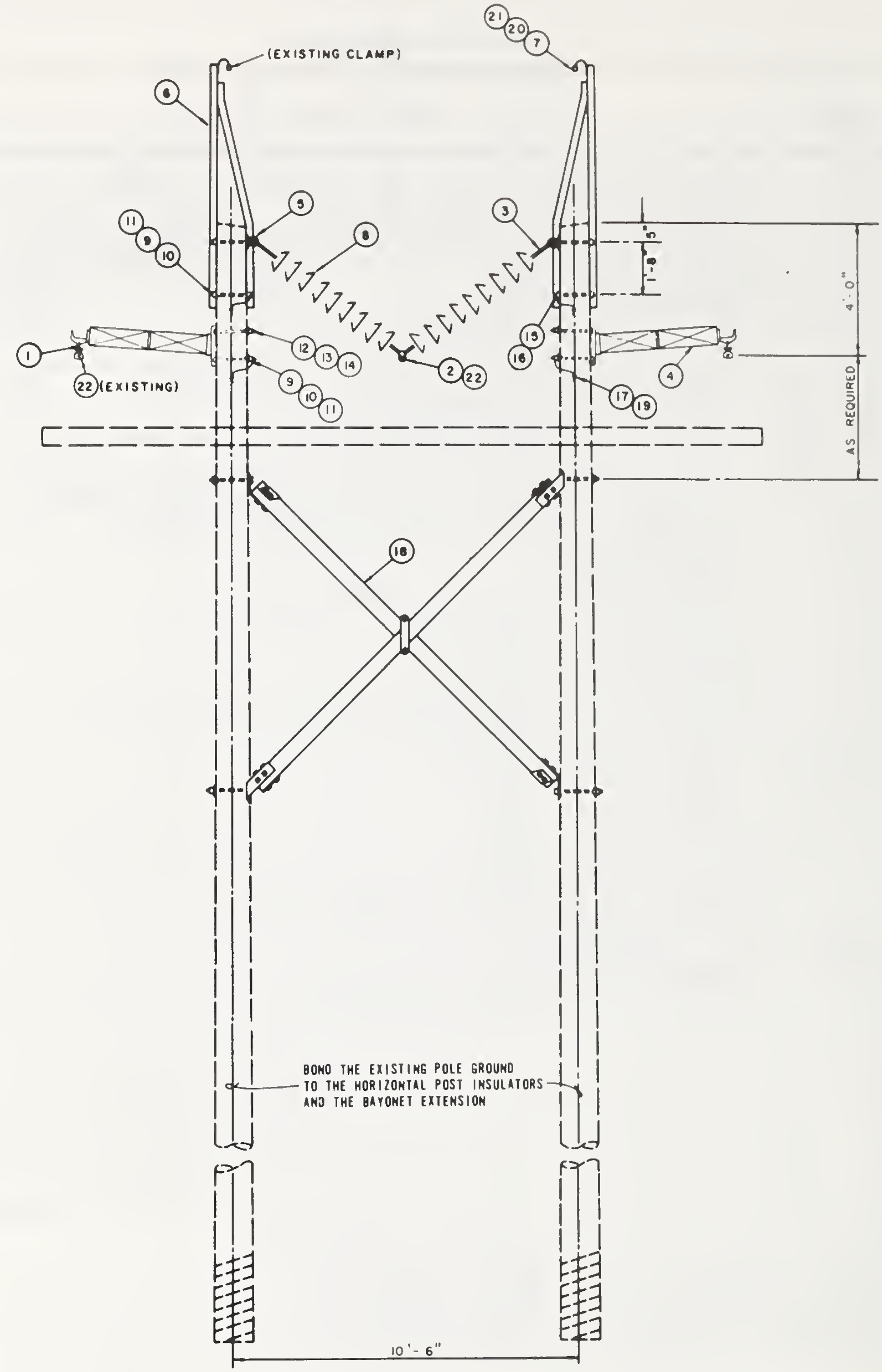
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	2	3 5/8" x 7½" x 24'- 0" WOOD CROSSARM	g
2	4	ADJUSTABLE SPACERS, HUGHES NO. 3400	
3	2	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
4	2	OHGW SUSPENSION CLAMP	m
5	1	OHGW SUPPORT ASSEMBLY TM-109	
6	4	5/8" x REQUIRED LENGTH MACHINE BOLT	c
7	4	RIBBED TIE PLATE, 3" x 7½" x 1/4" HUGHES 1005	
8	2	7/8" x REQUIRED LENGTH, THREADED ROD	
9	AS REQ.	5 3/4" x 10" SUSPENSION INSULATOR	k
10	2	BALL CLEVIS, HOT LINE, "Y" TYPE, BETHEA/NATIONAL YCBHL-65	
11	1	VEE STRING, SOCKET EYE ASSEMBLY, BETHEA/NATIONAL VSE- ----	
12	2	SUSPENSION HOOK	eh
13	4	CURVED WASHER, 11/16" HOLE HUGHES SW4-60	
14	2	SPRING WASHER, 15/16" HOLE	aw
15	4	LOCKNUT FOR 5/8" BOLT	ek
16	4	GAIN PLATE, 3" x 7½" x 1/4", HUGHES 1004	
17	3	CONDUCTOR SUSPENSION CLAMP	
18	AS REQ'D.	X-BRACE ASSEMBLY, TM-110	
19	4	LOCKNUT FOR 7/8" BOLT	ek
20	2	SOCKET EYE ULT. 30,000#	
21	2	NUT, 5/8" HUGHES N60	
22	2	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
23	AS REQ.	NO. 6 COPPERWELD	cj
24	2	COMPRESSION CONNECTOR FOR GROUNDWIRE	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TH-1G TO TH-VS
(69KV TO 138KV)

DATE:12-80 | FIG. 147



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. ADDITIONAL GROUND CLEARANCE MAY BE OBTAINED BY MOUNTING THE CONDUCTOR IN A HORIZONTAL POST CLAMP POSITION.
3. THE EXISTING CROSSARM(S) CAN BE LEFT IN PLACE TO MAKE THE STRUCTURE MORE RIGID IF THE PORTION UNDER EACH HORIZONTAL POST INSULATOR IS REMOVED.

CONVERSION STRUCTURE
TH-1G TO TH-HPX
(69 KV TO 138 KV)

DATE: 12-80 | FIG. 148

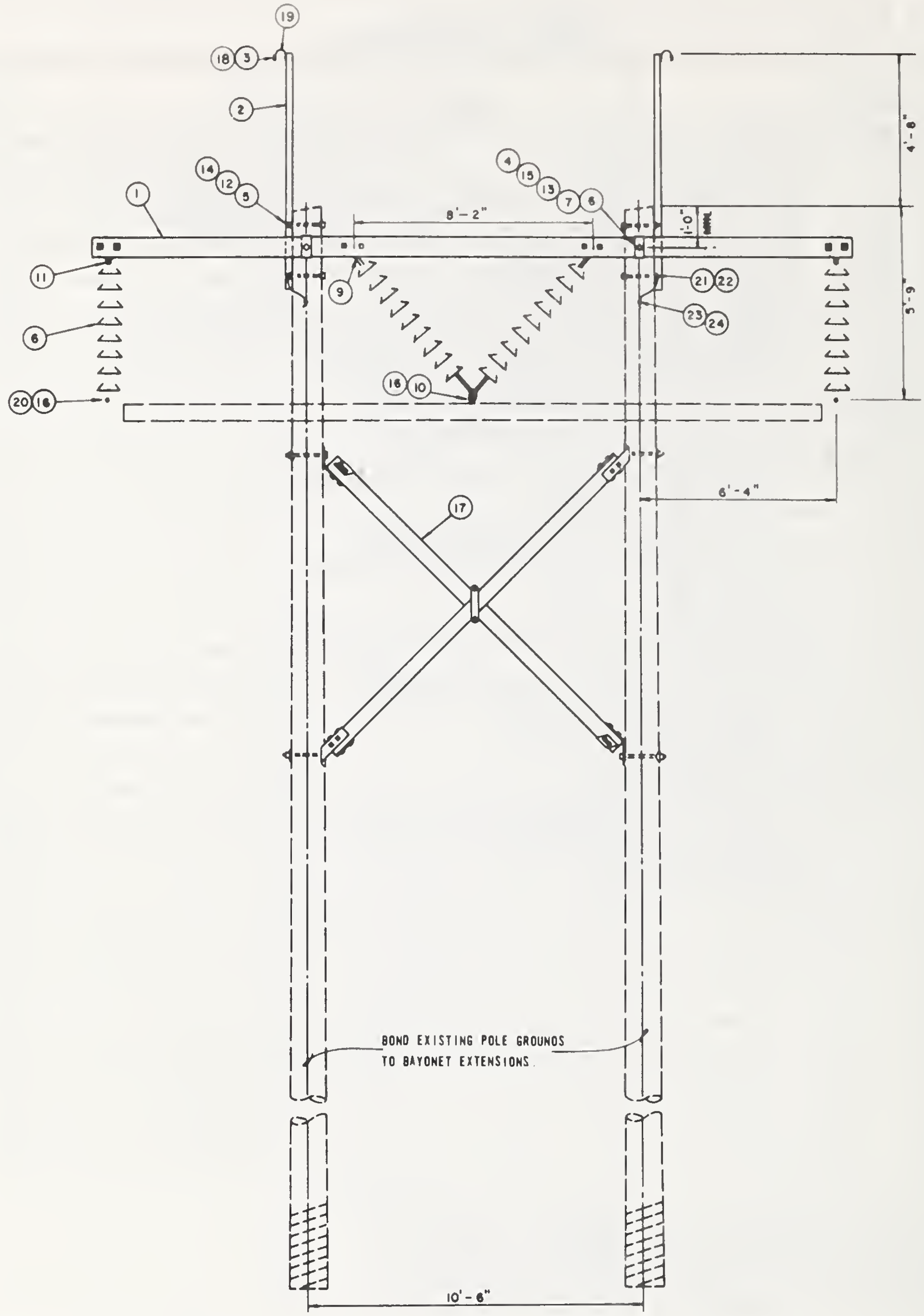
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	2	ANCHOR SHACKLE	bo
2	1	VEE STRING SOCKET EYE ASSEMBLY BETHEA/NATIONAL VSE----	
3	2	HOT LINE "Y" CLEVIS BALL BETHEA/NATIONAL YCBHL-65	
4	2	HORIZONTAL POST INSULATOR, 138KV LAPP 70148	
5	2	EYELET, 5/8" JOSLIN J1126	
6	2	STEEL BAYONET, CORNER, 84", JOSLYN #J1139	
7	2	GOOSENECK BAYONET BRACKET, JOSLIN J2529	
8	AS REQ.	5 3/4" x 10" SUSPENSION INSULATOR	k
9	6	5/8" x REQUIRED LENGTH MACHINE BOLT	c
10	2	CURVED WASHER, 11/16" HOLE, HUGHES SW4-60	
11	6	LOCKNUT FOR 5/8" BOLT	ek
12	2	3/4" x REQUIRED LENGTH MACHINE BOLT	c
13	2	CURVED WASHER, 13/16" HOLE, HUGHES SW4-70	
14	2	LOCKNUT FOR 3/4" BOLT	ek
15	4	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
16	4	NUT 5/8" HUGHES N60	
17	4	COMPRESSION CONNECTOR FOR GROUNDWIRE	
18	1	X-BRACE ASSEMBLY, TM-110	
19	AS REQ.	NO. 6 COPPERWELD	cj
20	2	OHGW SUSPENSION CLAMP	m
21	2	Y-CLEVIS EYE FOR OHGW CLAMP, LAPP 7858	
22	2	SUSPENSION CLAMP	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TH-1G TO TH-HPX
(69KV TO 138KV)

DATE: 12-80 | FIG. 149



NOTES

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. WOOD POLE GAINING AND GAIN PLATES MAY BE ELIMINATED WITH THE INSTALLATION OF GRID GAINS (BETHEA NATIONAL CAG-54-7) WHEN SPECIFIED BY THE ENGINEER.
3. THE LOCATION AND QUANTITY OF CROSSBRACES IS TO BE DETERMINED BY THE ENGINEER.

CONVERSION STRUCTURE
TH-1G TO TH-24A
(69KV TO 138KV)

DATE: 12-80

FIG. 150

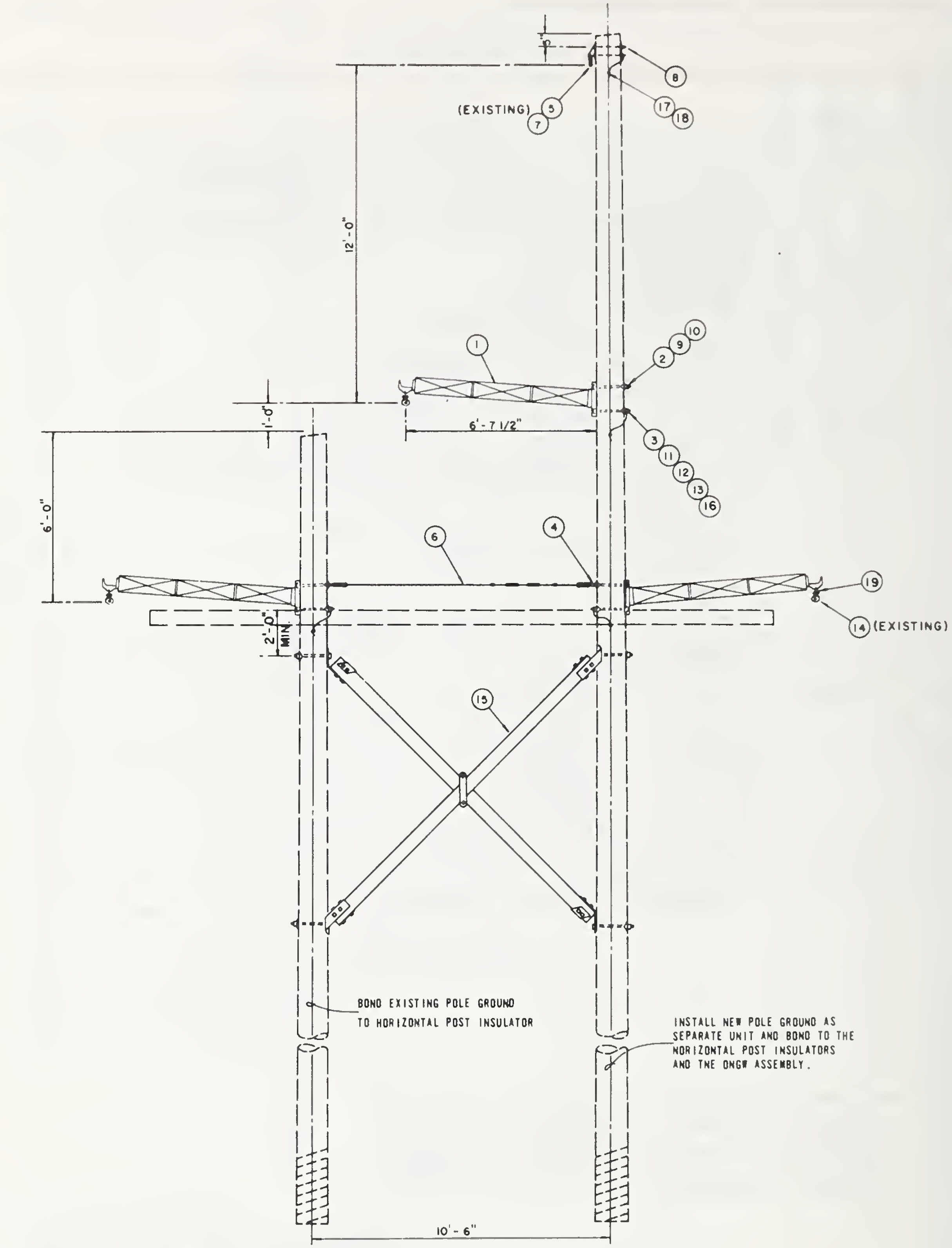
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	ITEM
1	2	3 5/B" x 7½" x 24'-0" WOOD CROSSARM ASSEMBLED WITH	g
		4-ADJUSTABLE SPACERS, HUGHES NO. 3400	
2	2	STEEL BAYONET, 3" x 3" x 1/4" x B4", JOSLYN #1134	
3	2	OHGW SUSPENSION UNIT	m
4	4	LOCKNUT FOR 7/8" BOLT	ek
5	4	5/8" x REQUIRED LENGTH MACHINE BOLT	c
6	4	RIBBED TIE PLATF, 3" x 7½" x 1/4", HUGHES 1005	
7	2	7/B" x REQUIREO LENGTH, THREAOEO ROD	
B	AS REQ.	5 3/4" x 10" SUSPENSION INSULATOR	k
9	2	BALL CLEVIS, HOT LINE, "Y" TYPE, BETHEA/NATIONAL YCBHL-65	
10	1	VEE STRING, SOCKET EYE ASSEMBLY, BETHEA/NATIONAL VSE------	
11	2	SUSPENSION HOOK	eh
12	4	CURVED WASHER, 11/16" HOLE, HUGHES SW4-60	
13	2	SPRING WASHER, 15/16" HOLE	aw
14	4	LOCKNUT FOR 5/B" BOLT	ek
15	4	GAIN PLATE, 3" x 7½" x 1/4", HUGHES 1004	
16	3	CONOUCTOR SUSPENSION UNIT	
17	AS REQ'O.	X-8RACE ASSEM8LY, TM-110	
18	2	Y-CLEVIS EYE FOR OHGW CLAMP, LAPP 7858	
19	2	GOOSENECK, JOSLIN J2529	
20	2	SOCKET EYE ULT. 30,000#	
21	2	NUT - 5/8", HUGHES N60	
22	2	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
23	AS REQ'D.	NO. 6 COPPERWELD	
24	2	COMPRESSION CONNECTOR FOR GROUNDWIRE	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY COOE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIEO TO IOENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TH-1G TO TH-24A
(69KV TO 138KV)

DATE: 12-80 | FIG. 151



NOTES.

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. ADDITIONAL GROUND CLEARANCE CAN BE OBTAINED BY INSTALLING THE CONDUCTOR IN A HORIZONTAL POST CLAMP POSITION.
3. THE LOCATION AND QUANTITY OF CROSSBRACES WILL BE DETERMINED BY THE ENGINEER.

CONVERSION STRUCTURE
TH-1G TO TM-161MT
(69KV TO 161KV)

DATE: 12-80

FIG. 152

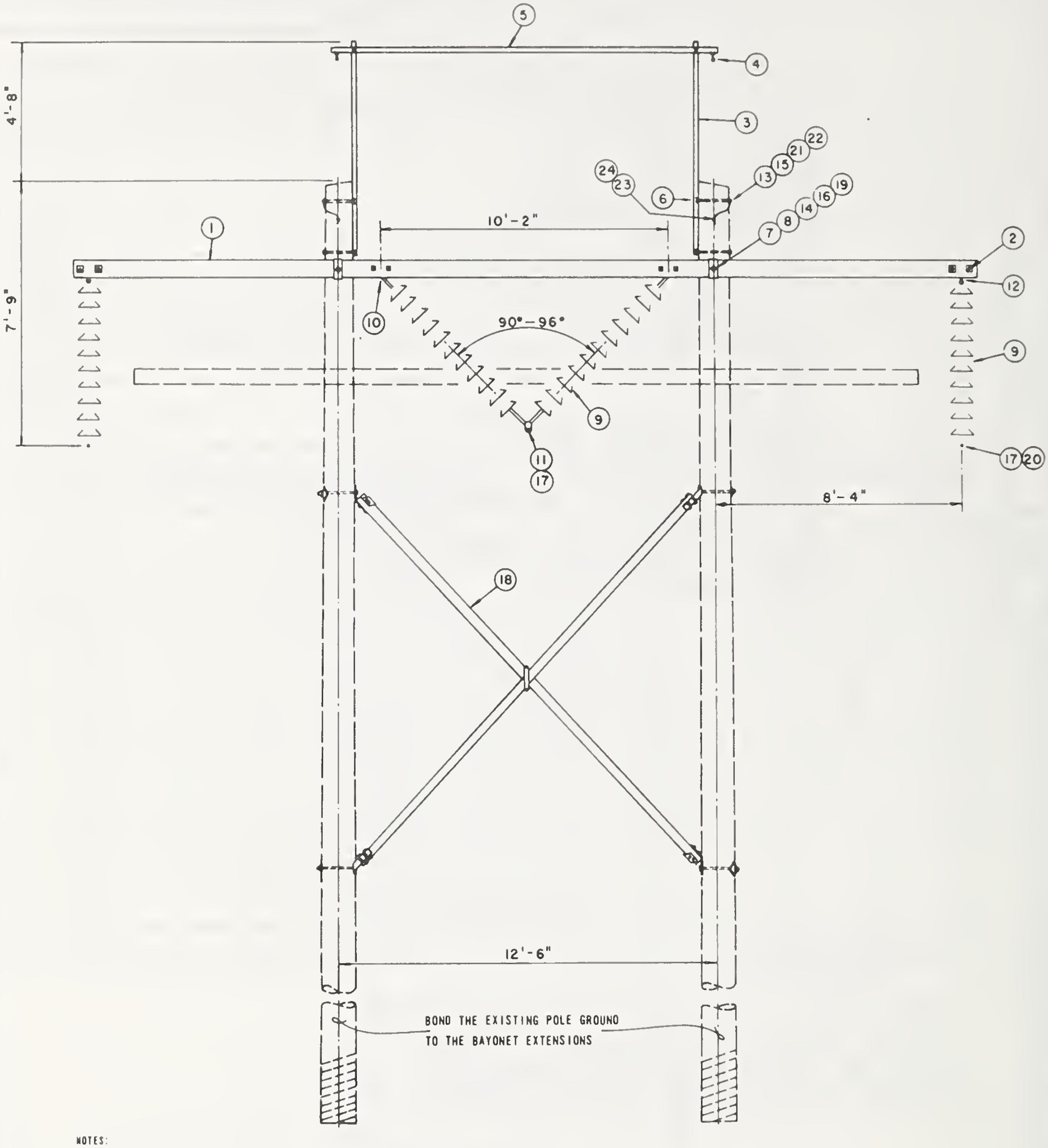
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	3	HORIZONTAL POST INSULATOR, 161KV LAPP 76D73A	
2	1	3/4'' x REQUIRED LENGTH MACHINE BOLT	c
3	3	5/8" x REQUIRED LENGTH MACHINE BOLT	c
4	2	OVERHEAD GUY ATTACHMENT, TG-19, 3/4" EYEBOLT	
5	1	GROUND WIRE CABLE SUPPORT	ed
6	1	OVERHEAD GUY UNIT, TG-15	
7	1	GROUND WIRE SUSPENSION CLAMP	m
8	1	GROUND WIRE CLAMP	dp
9	1	WASHER, CURVED, 4" x 4" x 1/4" WITH 13/16" HOLE	d
10	1	3/4" LOCKNUT	ek
11	3	WASHER, SQUARE, GALV. 2¼" x 2¼" x 13/16", 11/16" HOLE	d
12	3	NUT 5/8", HUGHES N60	
13	5	5/8" LOCKNUT	ek
14	3	CONDUCTOR SUSPENSION CLAMP	
15	AS REQ.	X-BRACE ASSEMBLY, TM-110	
16	3	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
17	AS REQ.	NO. 6 COPPERWELD	
18	4	COMPRESSION CONNECTOR FOR GROUNDWIRE	
19	3	ANCHOR SHACKLE	bo

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TH-1G TO TH-161MT
(69KV TO 161KV)

DATE: 12-80 FIG. 153



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. WOOD POLE GAINING AND GAIN PLATES MAY BE ELIMINATED WITH THE INSTALLATION OF GRID GAINS (BETHEA NATIONAL CAG-54-7) WHEN SPECIFIED BY THE ENGINEER.
3. THE LOCATION AND QUANTITY OF CROSSBRACES IS TO BE DETERMINED BY THE ENGINEER.

CONVERSION STRUCTURE TH-1A TO TH-VS (115 KV TO 161 KV)		
DATE: 12-80	FIG. 154	

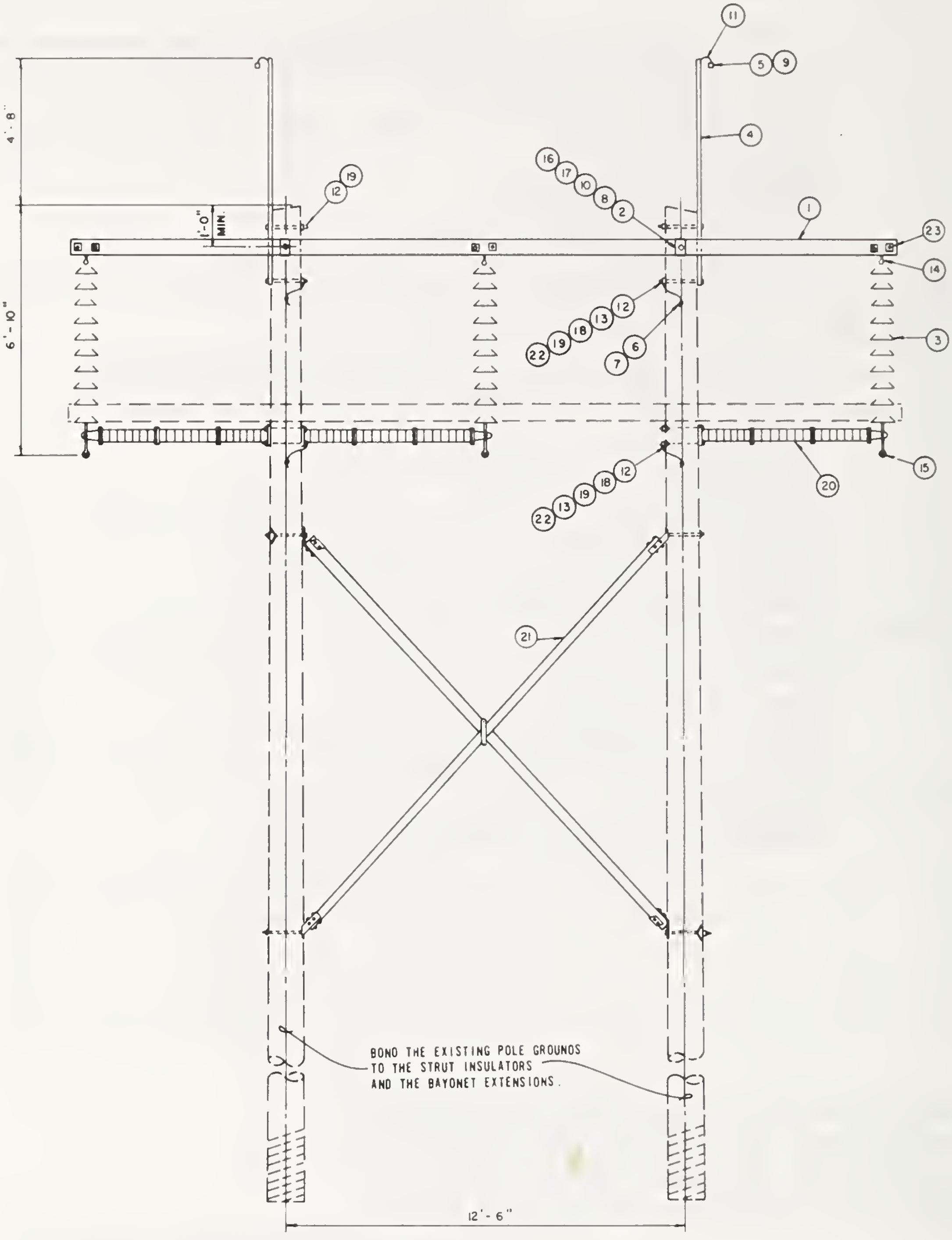
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	2	3 5/8" x 9 3/B" x 30'- 0" WOOD CROSSARM	g
2	4	ADJUSTABLE SPACERS, HUGHES NO. 3400	
3	2	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
4	2	OHGW SUSPENSION CLAMP	m
5	1	OHGW SUPPDRT ASSEMBLY TM-1D9	
6	4	5/B" x REQUIRED LENGTH MACHINE BOLT	c
7	4	RIBBED TIE PLATE, 3" x 9 3/8" x 1/4" HUGHES 1005	
8	2	7/B" x REQUIRED LENGTH, THREADED ROD	
9	AS REQ.	5 3/4" x 10" SUSPENSION INSULATOR	k
10	2	BALL CLEVIS, HOT LINE, "Y" TYPE, BETHEA/NATIONAL YCBHL-65	
11	1	VEE STRING, SOCKET EYE ASSEMBLY, BETHEA /NATIONAL VSE- ----	
12	2	SUSPENSION HOOK	eh
13	4	CURVED WASHER, 11/16" HOLE, HUGHES SW 4-6D	
14	2	SPRING WASHER, 15/16" HDLE	aw
15	4	LOCKNUT FOR 5/8" BOLT	ek
16	4	GAIN PLATE, 3" x 9 3/8" x 1/4", HUGHES 1004	
17	3	CONOUCTOR SUSPENSION CLAMP	
18	AS REQ'O.	X-BRACE ASSEMBLY, TM-11D	
19	4	LOCKNUT FOR 7/8" BOLT	
20	2	SOCKET EYE ULT. 30,000 #	
21	2	NUTS 5/8", HUGHES N60	
22	2	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
23	AS REQ'O	NO. 6 COPPERWELO	cj
24	2	COMPRESSION CONNECTOR FOR GROUNOWIRE	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY COOE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IOENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TH-1A TD TH-VS
(115KV TO 161KV)

DATE:12-80 | FIG. 155



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. WOOD POLE GAINING AND GAIN PLATES MAY BE ELIMINATED WITH THE INSTALLATION OF GRID GAINS (BETHEA NATIONAL CAG-54-7) WHEN SPECIFIED BY THE ENGINEER.
3 THE LOCATION AND QUANTITY OF CROSSBRACES IS TO BE DETERMINED BY THE ENGINEER.

CONVERSION STRUCTURE TH-1A TO TH-HFS (115 KV TO 161 KV)		
DATE 12-80	FIG. 156	

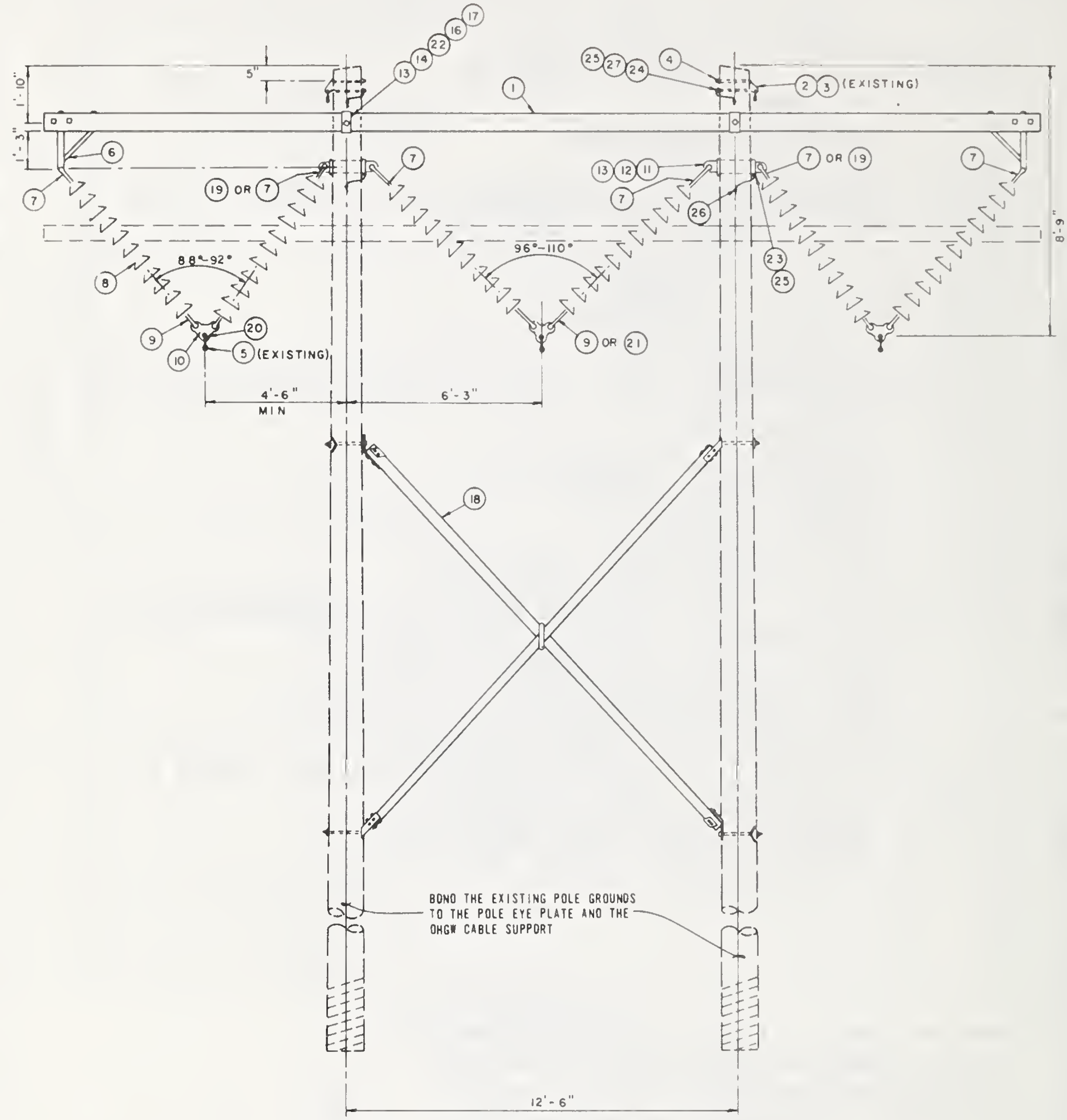
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	2	5 3/8" x 7 5/8" x 26'- 0" WOOD CROSSARM,	g
2	2	RIBBED TIE PLATE, HUGHES 1005	
3	AS REQ.	5 3/4" x 10" SUSPENSION INSULATOR	k
4	2	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
5	2	GROUNO WIRE SUSPENSION CLAMP	m
6	AS REQ.	NO. 6 COPPERWELD	cj
7	4	COMPRESSION CONNECTOR FOR GROUNDWIRE	
8	2	7/8" x REQUIRED LENGTH, THREADEO ROO	
9	2	Y-CLEVIS EYE FOR OHGW CLAMP	
10	4	LOCKNUT FOR 7/8" BOLT	ek
11	2	GOOSENECK, JOSLIN J2529	
12	8	LOCKNUT FOR 5/8" 8OLT	ek
13	4	NUT 5/8", HUGHES N 60	
14	3	SUSPENSION HOOK	eh
15	3	SUSPENSION CLAMP & CONNECTING PIECE	ei
16	2	SPRING WASHER 15/16" HOLE	aw
17	4	GAIN PLATE, HUGHES 1004	
18	8	5/8" x REQUIREO LENGTH, MACHINE BOLT	c
19	8	4" x 4" x 3/16" SQ. CURVEO WASHER, 11/16" HOLE HUGHES SW4-60	
20	3	STRUT ASSEMBLY, CONSISTING OF: MOUNTING BOLT UNIT	
		(LAPP #L-79032); CLEVIS AOAPTER (LAPP #79031-A);	
		STRUT INSULATOR COMBINATION (2 EA. LAPP #56443-70);	
		CLEVIS AOAPTER (LAPP #78869-B); SOCKET EYE	
		(LAPP #48215-A); CLEVIS EYE (8REWER TITCHENER CORP. 3098A OR B)	
21	AS REQ.	X-BRACE ASSEMBLY, TM-110 (AS REQUIREO)	
22	4	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
23	4	ADJUSTABLE SPACERS, HUGHES NO. 3400	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY COOE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. ANO CATALOG NO. ARE SPECIFIEO TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TH-1A TO TH-HFS
(115KV TO 161KV)

DATE:12-80 FIG. 157



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. WOOD POLE GAINING AND GAIN PLATES MAY BE ELIMINATED WITH THE INSTALLATION OF GRID GAINS (BETHEA NATIONAL CAG-54-7) WHEN SPECIFIED BY THE ENGINEER.
3. THE LOCATION AND QUANTITY OF CROSSBRACES IS TO BE DETERMINED BY THE ENGINEER.

CONVERSION STRUCTURE TH-1A TO TH-161MV (115KV TO 161KV)	
DATE: 12-80	FIG. 158

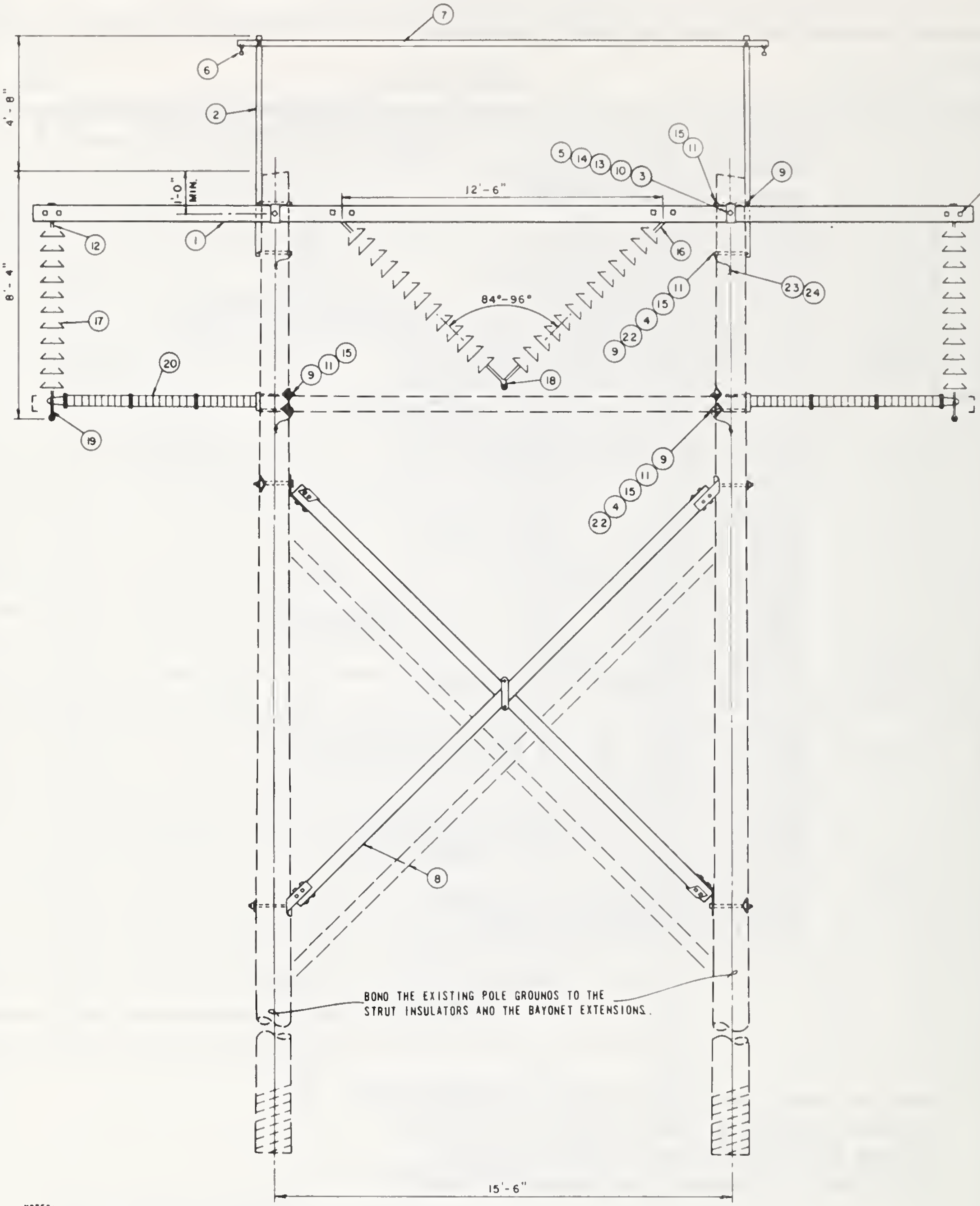
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	2	CROSSARM, 3 5/8" x 9 3/8" x 32'-0" W/5 ADJUSTABLE SPACERS	g
2	2	GROUND WIRE CABLE SUPPORT	ed
3	2	GROUND WIRE SUSPENSION UNIT	m
4	4	LOCKNUT FOR 5/8" BOLT	ek
5	3	CONDUCTOR SUSPENSION CLAMP	
6	2	SWINGING ANGLE BRACKET, TM-111E	
7	6	BALL CLEVIS, HOT LINE, "Y" TYPE, BETHEA/NATIONAL YCBHL-65	
8	AS REQ.	5¾" x 10" SUSPENSION INSULATOR	k
9	6	SOCKET, Y-CLEVIS BREWER TITCHENER 3068	
10	3	VEE STRING YOKE PLATE BREWER TITCHENER 8571	
11	4	POLE EYE PLATE BETHEA/NATIONAL #PE6-87	
12	4	MACHINE BOLT, 7/8" x REQUIRED LENGTH	c
13	8	LOCKNUT FOR 7/8" BOLT, MF TYPE	ek
14	2	THREADED ROD 7/8" x REQUIRED LENGTH	
15	2	NUT FOR 7/8" BOLT, HUGHES N80	
16	2	SPRING WASHER, 15/16" HOLE	
17	4	RIBBED TIE PLATE, 3" x 9½" x 1/4", HUGHES 1005	
18	AS REQ.	X-BRACE ASSEMBLY, TM-110	
19	AS REQ.	Y-CLEVIS BALL BREWER TITCHENER 3030	
20	3	ANCHOR SHACKLE	bo
21	AS REQ.	SOCKET Y-CLEVIS, HOT LINE BREWER TITCHENER 3096	
22	4	GAIN PLATE, HUGHES 1004	
23	2	BONDING CLIP FOR 7/8" BOLT, HUGHES 2727.8	
24	2	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
25	AS REQ.	NO. 6 COPPERWELD	cj
26	4	COMPRESSION CONNECTOR FOR GROUNDWIRE	
27	2	NUT FOR 5/8" BOLT, HUGHES N60	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TH-1A TO TH-161MV
(115KV TO 161KV)

DATE: 12-80 | FIG. 159



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. WOOD POLE GAINING AND GAIN PLATES MAY BE ELIMINATED WITH THE INSTALLATION OF GRID GAINS (BETHEA/NATIONAL CAG-54-7) WHEN SPECIFIED BY THE ENGINEER.
3. THE LOCATION AND QUANTITY OF CROSSBRACES IS TO BE DETERMINED BY THE ENGINEER.

CONVERSION STRUCTURE TH-10 TO TH-HFST (161 KV TO 230 KV)	
DATE 12-80	FIG. 160

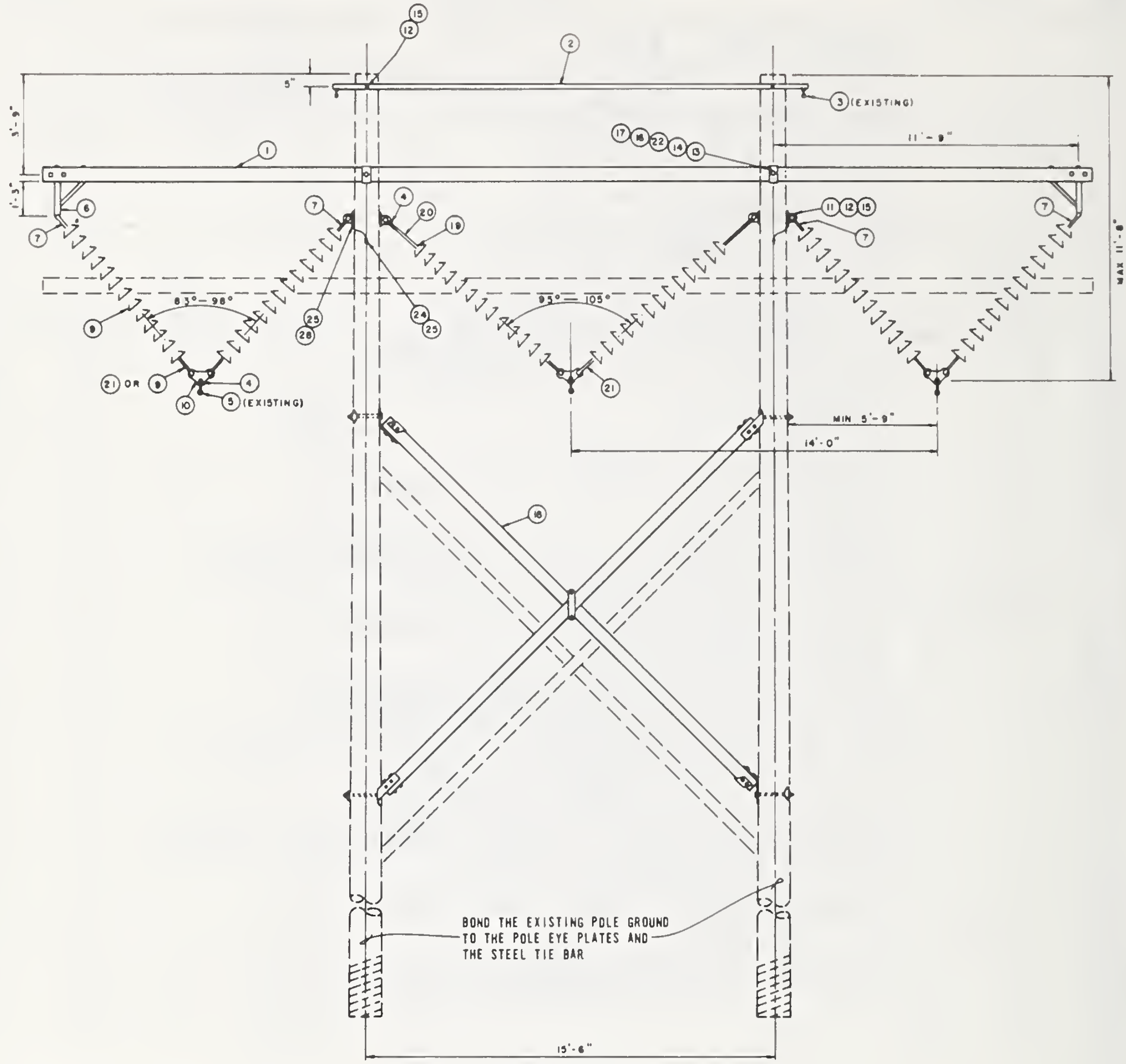
LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	2	CROSSARM, 3 5/8" x 9 3/8" x 32'- 0"	g
2	2	STEEL BAYONET, 3" x 3" x 1/4" x 84", JOSLYN #1134	
3	2	THREADED ROD 7/8" x REQUIRED LENGTH	
4	4	NUT FOR 5/8" BOLT, HUGHES N60	
5	4	LOCKNUT FOR 7/8" BOLT, MF TYPE	
6	2	OHGW SUSPENSION CLAMP	m
7	1	OHGW SUPPORT ASSEMBLY, TM-109	
8	AS REQ.	X-BRACE ASSEMBLY, TM-110	
9	8	5/8" x REQUIRED LENGTH, MACHINE BOLT	
10	4	GAIN PLATE, 3" x 9½" x 1/4", HUGHES 1004	
11	8	CURVED WASHER 4" x 4" x 1/4" x 11/16" HOLE	
12	2	SUSPENSION HOOK	eh
13	2	SPRING WASHER, 15/16" HOLE	
14	4	RIBBED TIE PLATE, 3" x 9½" x 1/4", HUGHES 1005	
15	8	LOCKNUT FOR 5/8" BOLT	ek
16	2	BALL CLEVIS, HOTLINE, "Y" TYPE, BETHEA/NATIONAL YCBHL-65	
17	AS REQ.	5¾ x 10" SUSPENSION INSULATOR	k
18	1	VEE STRING SOCKET EYE ASSEMBLY, BETHEA/NATIONAL VSE-____	
19	3	CONDUCTOR SUSPENSION CLAMP	
20	2	STRUT ASSEMBLY, CONSISTING OF: MOUNTING BOLT UNIT	
		(LAPP #L-79032); CLEVIS ADAPTER (LAPP #79031-A);	
		STRUT INSULATOR COMBINATION(LAPP 2-#60103 & 1 - #56443) EA.	
		CLEVIS ADAPTER (LAPP #78869-B); SOCKET EYE	
		(LAPP #48215-A); CLEVIS EYE (BREWER TITCHENER CORP. 3098A OR B)	
21	4	ADJUSTABLE SPACERS, HUGHES NO. 3400	
22	4	BONDING CLIP FOR 5/8" BOLT, HUGHES 2727.6	
23	AS REQ.	NO. 6 COPPERWELD	cj
24	4	COMPRESSION CONNECTOR FOR GROUNDWIRE	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL. ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TH-10 TO TH-HFST
(161KV TO 230KV)

DATE: 12-80 | FIG. 161



NOTES:

1. INSTALL A TREATED PLUG IN EACH UNUSED HOLE.
2. WOOD POLE GAINING AND GAIN PLATES MAY BE ELIMINATED WITH THE INSTALLATION OF GRID GAINS (BETHEA/NATIONAL CAG-54-7) WHEN SPECIFIED BY THE ENGINEER.
3. THE LOCATION AND QUANTITY OF CROSSBRACES IS TO BE DETERMINED BY THE ENGINEER.

CONVERSION STRUCTURE TH-10 TO TH-230MV (161KV TO 230KV)		
DATE: 12-80	FIG. 162	

LIST OF MATERIALS

DWG. REF.	REQ'D.	DESCRIPTION	* ITEM
1	2	CROSSARM, 3 5/8" x 9 3/8" x 40'-0" W/5 ADJUSTABLE SPACERS	g
2	1	GROUNDWIRE CABLE SUPPORT ASSEMBLY, TM-109	
3	2	GROUNDWIRE SUSPENSION CLAMP	m
4	5	ANCHOR SHACKLE	bo
5	3	CONDUCTOR SUSPENSION CLAMP	
6	2	SWINGING ANGLE BRACKET, TM-111E	
7	4	BALL CLEVIS, HOT LINE, "Y" TYPE, BETHEA/NATIONAL YC8HL-65	
8	AS REQ.	5 3/4" x 10" SUSPENSION INSULATOR	k
9	4	SOCKET, Y-CLEVIS BREWER TITCHNER 3038	
10	3	VEE STRING YOKE PLATE BREWER TITCHNER 8571	
11	4	POLE EYE PLATE BETHEA/NATIONAL PE 6-87	
12	4	MACHINE BOLT, 7/8" x REQUIRED LENGTH	c
13	8	LOCKNUT FOR 7/8" BOLT, MF TYPE	ek
14	2	THREADED ROD 7/8" x REQUIRED LENGTH	
15	2	NUT FOR 7/8" BOLT	
16	2	SPRING WASHER, 15/16" HOLE	
17	4	RIBBED TIE PLATE, 3" x 9½" x 1/4" HUGHES 1005	
18	AS REQ.	X-BRACE ASSEMBLY, TM-110	
19	2	Y-CLEVIS BALL, BREWER TITCHENER 3030	
20	2	OVAL EYE HOT LINE LINK, BREWER TITCHENER 3703	
21	2	SOCKET Y-CLEVIS HOT LINE, BREWER TITCHENER 3096	
22	4	GAIN PLATE, HUGHES 1004	
23	2	BONDING CLIP FOR 7/8" BOLT, HUGHES 2727.8	
24	AS REQ.	NO. 6 COPPERWELD	cj
25	2	COMPRESSION CONNECTOR FOR GROUND WIRE	
26	2	NUT FOR 7/8" BOLT, HUGHES N80	

* WHEN AVAILABLE, A REA LIST OF MATERIAL CATEGORY CODE IS GIVEN. WHERE THIS IS NOT POSSIBLE, A MFG. AND CATALOG NO. ARE SPECIFIED TO IDENTIFY MATERIAL ANY MATERIAL EQUIVALENT TO THAT NOTED MAY BE USED.

CONVERSION STRUCTURE
TH-10 TO TH-230MV
(161KV TO 230KV)

DATE:12-80 | FIG. 163

APPENDIX

CASE STUDY OF 69 KV TO 115 KV LINE UPRATING

INTRODUCTION:

This analysis provides a brief summary of a 69 kV to 115 kV transmission line uprating study. The original 69 kV line was constructed on the standard REA TS-1 single-pole structure (Figure 1). The uprated 115 kV line structure was constructed on the TH-1AM structure (Figure 2).

ANALYSIS:

The original 69 kV line was designed and constructed in 1951-1952 under the safety guidelines of the 4th Edition of the National Electrical Safety Code (NESC) and the then existing REA Transmission Line Design Guides. The uprated 115 kV line was designed in 1979 in accordance with the 1977 Edition of the NESC and the 1972 REA Bulletin 62-1 and July 1978 "File With" REA Bulletin 62-1 vertical clearance requirements.

A tabulation of the original and uprated design criteria is provided below:

Original Design Summary	Uprated Design Summary
Conductor: #1/0 ACSR 6/1	477 MCM 26/7 ACSR
Shield Wire: 3/8" H.S. Steel	3/8" H.S. Steel
Loading: 1/2" Ice & 4# Wind @ 0° F	1/2" Ice & 4# Wind @ 0° F
Ruling Span: 500'	380'
Voltage: 69 kV	115 kV
Basic Poles: 50'Cl.3	(50'Cl.3 & 55'Cl.3) 1 ea.

The original 69 kV line had a design ruling span of 500 feet as compared with an actual ruling span of 380 feet based on structure locations. A check of several contemporary line projects revealed a similar practice.

Summation of moments at the groundline due to wind and ice loads revealed that the larger 477 MCM 26/7 conductor and two 3/8" H.S. Steel shield wires could be installed on the uprated TH-1AM tangent structure and provide a 4.0 safety factor under NESC Heavy Loading criteria. The maximum allowable sum of adjacent spans for several typical structure heights are:

TH-1AM (Ht. & Class)	Max. Sum of Adjacent Spans (S.F. = 4.0)
50 - 3	1,151 feet
55 - 3	1,136 feet
60 - 3	1,129 feet

The single crossarm (Type 55) of the TH-1AM structure has a maximum vertical span limitation of 822 feet under NESC H.L. conditions and a 4.0 safety factor.

The allowable sum of adjacent spans noted above and the vertical span allowed by the crossarm strength permitted existing poles and pole locations are to be used in spotting all tangent structures in the uprated line. Additional span lengths could have been attained by installing X-braces or using an assembled crossarm. The span lengths in the existing line, however, allowed the use of the unbraced, single-piece crossarm structure described above.

As a general rule, standard REA angle and deadend structures were called for at line angles and deadend points in the uprated line. No attempt was made to redesign or uprate existing 69 kV structure configurations. This rule was employed to assure ample strength and electrical clearances at these critical line locations.

The galloping ellipse patterns were calculated and plotted for the longest individual span in the line (590'). The single loop method of analysis was used and less than 10% overlap was detected; therefore, the structure spacing, wire sags, and maximum span length were concluded to be satisfactory.

INSPECTION/SURVEY:

A vital part of the design procedure in a line uprating is a thorough inspection of the existing line. A competent inspection crew should be assigned to foot patrol and inspect the entire line length. The inspection crew should use copies of the existing line plan and profile drawings. They should perform many checks including the following:

- Verify the elevation of the elevation profile.

- Verify the height and groundline circumference of each existing structure.

- Verify the height and survey station of each utility crossing.

- Report the location and extent of any right-of-way encroachment (house, barn, mobile home, radio/TV antenna, etc.).

- Verify survey station of all highway/road/railroad crossings.

- Report any land use changes (original pastureland now under cultivation, pivot irrigation now installed, etc.).

- Report any terrain changes (excavations, landfills, stock tanks, terraces, etc.).

- Report structure requiring line maintenance (ground or internal rot, damaged pole, etc.).

Line conversion or voltage uprating may warrant a complete new line survey. If the existing transit and level data is relatively recent (less than ten years) and the line route is not in a developing urban area, the existing survey information may be adequate if verified thoroughly by the foot patrol inspection noted above.

An important point to recognize in line uprating is the fact that the centerline of the uprated structure may not be the same centerline of the original structure. The original centerline of the TS-1 structure coincided with the original survey centerline. However, the centerline of the uprated TH-1AM structure was offset 1.91m (6'-3") from the original survey centerline. Because of the flatness of the terrain passed through in this study the offset did not create a real problem. However, a similar offset through heavily wooded or side sloping terrain might have been prohibitive.

RIGHT-OF-WAY:

The original TS-1 single pole 69 kV transmission line required only 15.24m (50 feet) of right-of-way (7.62m [25 feet] either side of the centerline). The uprated TH-1AM two pole 115 kV line requires a minimum of 22.86m (75 feet) of permanent right-of-way (9.14m [30 feet] from one side to the original centerline plus 12.19m [40 feet] on the other side to allow for centerline and conductor offset, blow-out and electrical clearance).

NOTIFICATION:

A "notice of intent to construct" is usually required by local regulatory agencies. This type of notification should be given even if it is not required by statute. Information concerning line route, structure configuration, wire size, minimum ground clearances, operating voltage, etc. should be sent to all local utilities, highway departments, county officials, pipeline companies, rural water cooperatives, Federal Aviation Agency, or any other group which may have facilities in the area or be affected by the new construction.

DESIGN DATA:

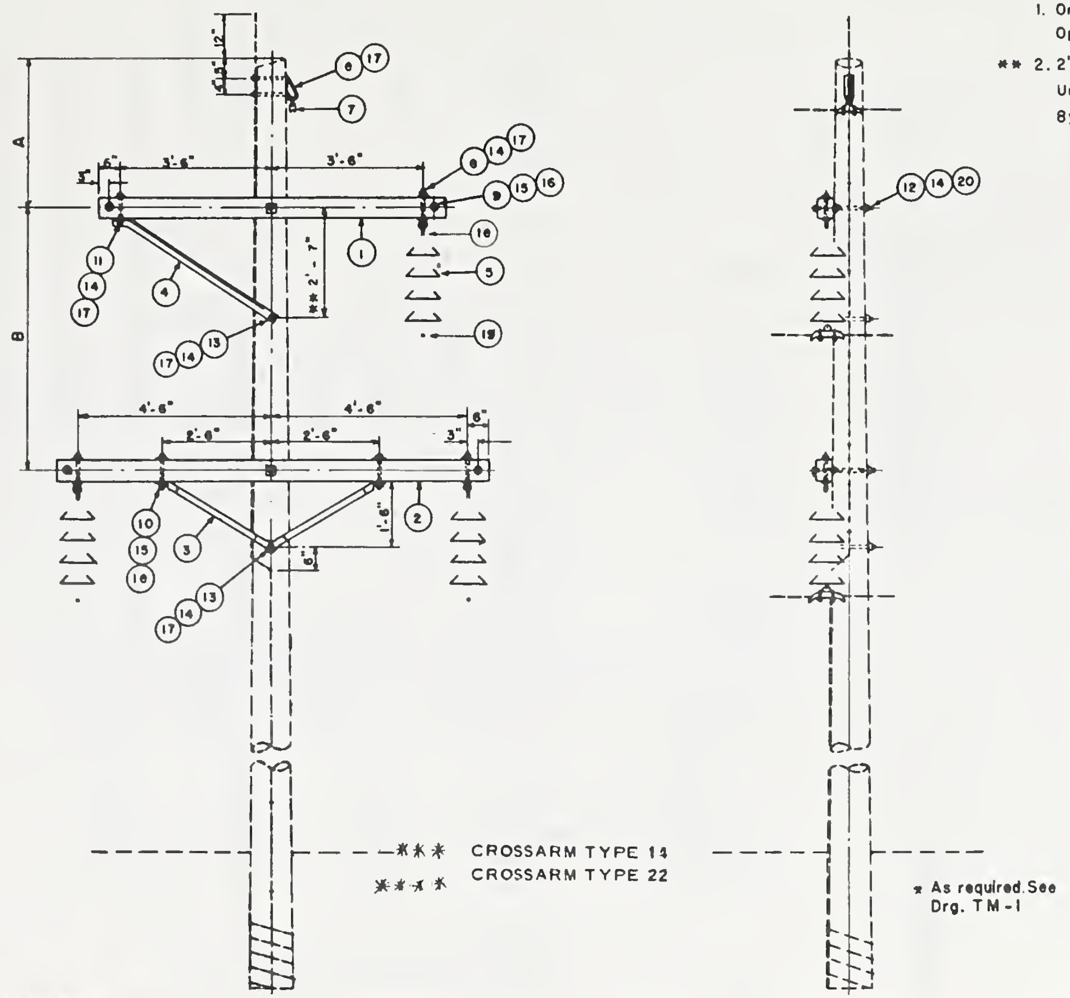
The following pages provide a design data summary of the TH-1AM uprated line and structure. One of the main advantages of using the TH-1AM configuration is that it allows an increased ground clearance of 1.68m (5'-6") over the ground clearance allowed by the original TS-1 structure. This provided enough additional ground clearance to allow use of larger conductor as well as voltage upgrading. (An additional 0.46m [1'-6"] of ground clearance could be provided by raising the crossarm to within 0.3048m [1'-0"] of the pole top of the original structure.)

The lightning shield angle of the TH-1AM structure is approximately 28 degrees to the outside phases.

NOTES:

1. On Straight Lines Items 6 and 7 May be Mounted On Opposite Of The Pole.

** 2. 2'-7" Dimension is Approximate. Proper Assembly Should Raise Unloaded Conductor Position 1 1/2 Inches Above Level Position By Tilting Crossarm.



DRG. NO.	DIMENSIONS A'	B
TS-1	3'-6"	6'-0"
TS-1X	4'-6"	7'-0"

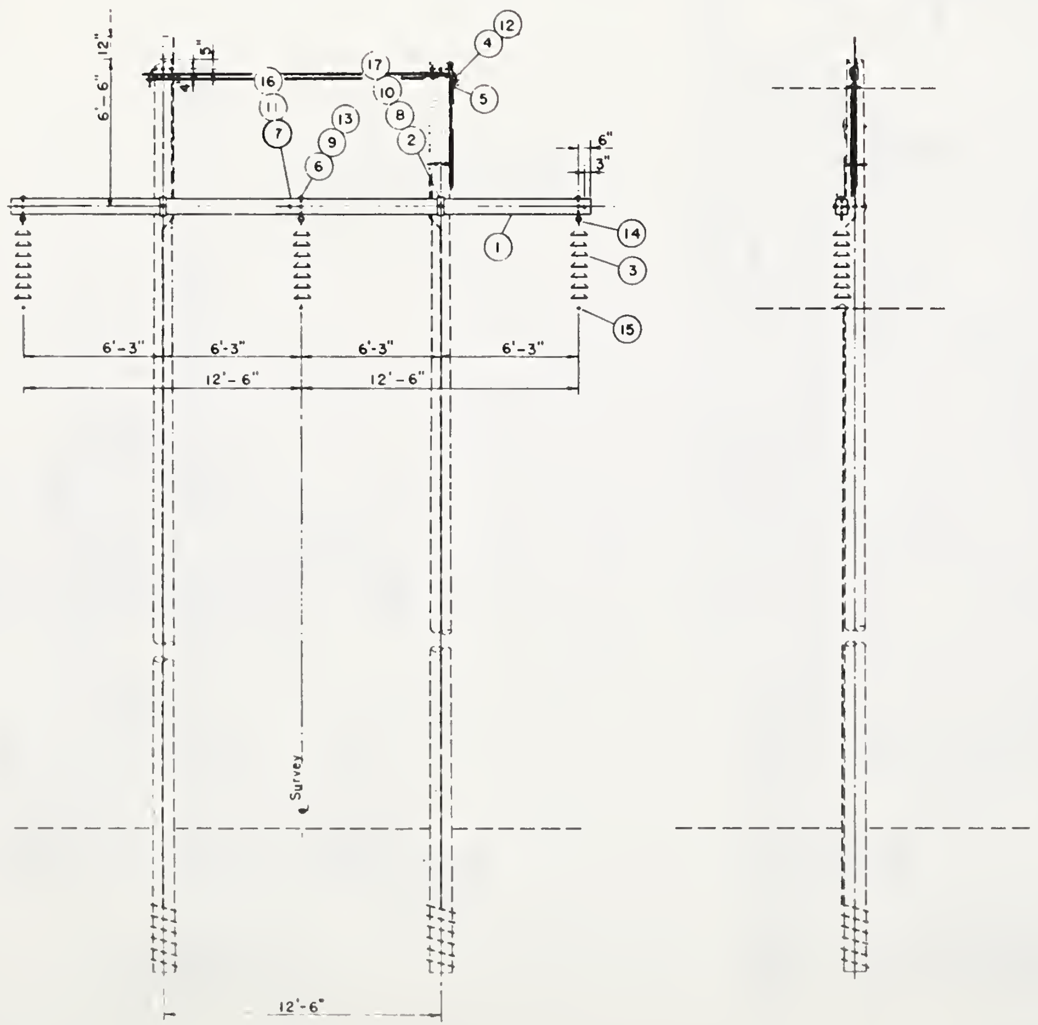
LIST OF MATERIAL

DRG. REF.	REQ'D	DESCRIPTION	ITEM
1	1	4 5/8" x 5 5/8" Wood Crossarm ***	g
2	1	4 5/8" x 5 5/8" Wood Crossarm ****	g
3	1	60" Wood Crossarm Brace	cu
4	1	48" Alloy Arm Brace	em
5	*	5 3/4"x10" Suspension Insulator	k
6	1	Ground Wire Cable Support	ed
7	1	Ground Wire Suspension Clamp	m
8	3	5/8"x8" Eye Bolt	o
9	4	1/2"x7" Machine Bolt	c
10	2	1/2"x8" Machine Bolt	c
11	1	5/8"x8" Machine Bolt	c
12	2	3/4"x18" Machine Bolt	c
13	2	5/8" Machine Bolt, Length as Required	c
14	13	2 1/4"x 2 1/4"x 3/16" Galv. Sq Washer, 13/16" Hole	d
15	10	1 3/8" Galv. Round Washer, 9/16" Hole	d
16	6	Locknuts for 1/2" Bolt	ek
17	8	Locknuts for 5/8" Bolt	ek
18	3	Suspension Hook	eh
19	3	Suspension Clamp and Connecting Piece	al
20	2	Locknuts for 3/4" Bolts	ek

TRANSMISSION LINE TANGENT STRUCTURE
____ KV SINGLE POLE SUSPENSION
(69 KV MAXIMUM)

1	REVISED	7-72	
Scale: NTS		Date. Feb. 1967	TS-1, TS-1X

Figure 1



* As required See Drg TM-1

LIST OF MATERIAL			
DRG REF	REQ'D	DESCRIPTION	ITEM
1	1	5 3/8" x 7 5/8" x 26'-0" Wood Crossarm, Type 55	g
2	2	Reinforcing Plate for 8" Crossarm	eg
3	*	5 3/4" x 10" Suspension Insulator	k
4	2	Ground Wire Cable Support	ed
5	2	Ground Wire Suspension Clamp	m
6	3	3/4" x 10" Eye Bolt	o
7	3	1/2" x 8" Machine Bolt	c
8	2	7/8" x reqd length, Machine Bolt	c
9	10	4" x 4" x 3/16" Galv Sq. Washer, 13/16" Hole	d
10	2	Locknuts for 7/8" Bolt	ek
11	3	Locknuts for 1/2" Bolt	ek
12	4	Locknuts for 5/8" Bolt	ek
13	5	Locknuts for 3/4" Bolt	ek
14	3	Suspension Hook	eh
15	3	Suspension Clamp and Connecting Piece	ei
16	6	2 1/4" x 2 1/4" Galv Sq Washer, 9/16" Hole	
17	2	4" x 4" x 3/16" Sq Curved Washer, 15/16" Hole	
		STEEL BAYONET	
		STEEL TIE BAR	

X-BRACED
TRANSMISSION LINE TANGENT STRUCTURE
H-FRAME SUSPENSION-TWO POLE
(115 KV MAXIMUM)

Scale None

Date

TH-1AM

Figure 2

CASE STUDY

TRANSMISSION LINE DESIGN DATA SUMMARY

1. Date: April 1979

2. Project Designation: ____

3. Line Identification: 115 kV Uprating

   (a) Length, miles: Transmission 34.5 (approx.)

   (b) Length, miles: Underbuild - - -

4. Voltage:

   (a) Transmission: Upgrade from 69 kV to 115 kV

   (b) Underbuild: - - -

5. Number of Phases on Underbuild: ____

6. Mechanical Data:

Item	Transmission Conductor	Overhead Ground Wire	Under-build	Common Neutral
Wire Code Word	Hawk			
Size (AWG)	447 MCM	3/8"		
Stranding	26/7	7		
Material	ACSR	H.S. Steel		
Diameter (in.)	0.858	0.360		
Area (sq.in.)	0.4356	0.07917		
Weight (lb/ft.)	0.6566	0.273		
Ultimate Strength	19,430#	10,800#		

7. National Electric Safety Code Loading Zone: Heavy

   (a) Ice, (in.) 1/2, (b) Wind (lb.) 4

   (c) Fahrenheit 0^{o}

8. Design Data:

1/2 " ICE 4 + .30 WIND	CONDUCTORS			
	Trans.	O.H.G.W.	Under-build	Common Neutral
Vertical Lb./Ft.	1.501	0.807		
Transverse Lb./Ft.	0.6193	0.4535		
Resultant + K Lb/Ft.	1.934	1.215		
LIMITING TENSION CONDITIONS (%)				
Initial 0° F/60° F	21.0/13.7	25.0/22.8		
Final 0° F/60° F	18.5/11.4	19.3/16.6		
Maximum	29.95	34.4		

9. Length of Span (ft.):

(a) Average (Est.) 380, (b) Maximum (Est.) 590

(c) Ruling 380'

10. Sag and Tension Chart Nos. 1-782, 1-1330

(a) Name of Company: Alcoa

11. Ruling Span, Sags and Tensions:

(a) Sags (Feet):

CONDITION	°F	Transmission		Overhead Ground Wire		Underbuild	
		Initial	Final	Initial	Final	Initial	Final
1/2 in. ice 4+K wind	0	5.98	6.01	5.97	5.97		
1/2 in. ice, no wind	32	5.83	6.19	4.86	5.06		
Bare, No Wind	-20	2.55	2.77	1.69	1.82		
Bare, No Wind	0	2.91	3.30	1.83	2.00		
Bare, No Wind	32	3.64	4.36	2.08	2.36		
Bare, No Wind	60	4.46	5.38	2.37	2.76		
Bare, No Wind	90	5.44	6.46	2.76	3.28		
Bare, No Wind	120	6.43	7.40	3.23	3.90		
Bare, No Wind	167	7.91	8.15	4.15	4.96		
Bare, No Wind	212	8.80	8.85	5.13	5.99		

11. Ruling Span, Sags and Tensions: (Continued)
(b) Tensions (Pounds):

CONDITION	°F	Transmission		Overhead Ground Wire		Underbuild	
		Initial	Final	Initial	Final	Initial	Final
1/2 in. ice 4+K wind	0	5819	5781	3712	3712		
1/2 in. ice, no wind	32	4652	4387	2999	2881		
Bare, No Wind	-20	4642	4288	2911	2712		
Bare, No Wind	0	4080	3589	2700	2466		
Bare, No Wind	32	3255	2719	2365	2090		
Bare, No Wind	60	2660	2205	2079	1788		
Bare, No Wind	90	2183	1837	1789	1502		
Bare, No Wind	120	1846	1606	1526	1266		
Bare, No Wind	167	1501	1459	1189	994		
Bare, No Wind	212	1351	1343	961	824		

(c) Slack Span:

(1) Length ________ Ft., (2) Design Tension ________ Lbs.

(3) Initial 60°F Sag __________ Ft.

(4) Initial 60°F Tension __________ Lb.

12. Minimum Conductor Ground Clearance at 167 °F Final Sag:

NATURE OF CLEARANCE	Transmission (Ft.)	Underbuild (Ft.)
(a) Track rails of railroads	32	
(b) Public Streets and Highways	24	
(c) Areas Accessible to Pedestrians	19	
(d) Cultivated Field	24	
(e) Along roads in rural districts	22	
(f) Additional allowance-Sag Template	1	
(g) Communications lines	8	
(h) Supply lines	6	
(i) Template Cut for a Clearance of	25	

13. Base Pole:

(a) Height 55' (new) 50' (Existing Pole) CL.3

(b) Class 3

(c) Depth of setting 7.5' (new pole) 7.0' (Existing Setting Depth)

(d) Type of Tangent Structure TH-1AM

14. Crossarm Dimensions:

(a) Width 5 3/8 in., (b) Height 7 5/8 in.

15. Structure Data:

ITEM	Crossarm	Pole
(a) Shear Parallel to Grain, lb. per sq. in.	1140	1140
(b) (1) Bending, lb. per sq. in.	8000	8000
(2) Compression, End Grain	7420	7420
(3) Compression, Across Grain*	910	910
(b) Species of Wood	D. Fir.	SYP
(c) Preservative	Penta	Penta
(1) Retention (lb.)	0.40	0.50
(2) Method	Pressure	Pressure

*Stress at proportional limit.

16. Span Length Limitations:

ITEM	Feet
(a) Normal Tangent Span On Level Ground	446
(b) Maximum Sum Of Adjacent Spans With Side Guys	- - -
(c) Maximum Sum Of Adjacent Spans Limited By Pole Strength (50'-3)	1151
(d) Maximum Vertical Span Limited By Strength of Crossarm	822

16. Span Length Limitations: (Continued)

ITEM	Feet
(e) Maximum Span Limited By Conductor Separation (1) Tangent Structure	896
(2) Tangent To Vertical Structure	- - -
(f) Maximum Sum Limited By Underbuild (1) Due to ________________	- - -

17. (a) Average number of line angles per mile ________________

(b) Maximum working load for Log Anchor:

(1) Five foot log 8,000 lbs.

(2) Eight foot log 16,000 lbs.

(3) Screw Anchors as per manufacturer's recommendation w/SF of 2.

(c) Guy Slope (L/~~H~~) 1:1 Unless Noted

(d) Maximum Design Tension in Guy Wire 3/8" H.S. Steel =5,400 Lbs.

(e) Elevation Above Sea Level:

(1) Maximum 4,200 Feet

(2) Minimum 3,600 Feet

18.

CONDUCTOR CLEARANCE:	Inches
(a) Normal Support	42
(b) Minimum to Support	26
(c) Minimum to Guy	33
(d) Climbing or Working Space for Underbuild	--

19. Tangent Structure Conductor Configuration: (Check One)

Single Pole: Delta ( ), Davit Arms ( ), Steel Arms ( ),

Horizontal ( ),

H-Frame: Horizontal (X), Delta ( )

20. Conductor Separation At Support

DISTANCE BETWEEN:	(VERTICAL)	(HORIZONTAL)
LOCATIONS	Feet	Feet
(a) OHGW to Upper Conductor [1] [2]		
Upper Conductor to Middle Conductor [1] [2]		
Upper Conductor to Lower Conductor [1] [2]		
Middle Conductor to Lower Conductor [1] [2]		
(b) Upper Conductor to Upper Conductor [2]		
Middle Conductor to Middle Conductor [2]		
Lower Conductor to Lower Conductor [2]		
(c) Horizontal Circuit Only:		
Upper Center Phase to Upper Right Phase	- - -	12.5
Upper Center Phase to Upper Left Phase	- - -	12.5
OHGW or Neutral to Closest Upper Conductor	9.3	5.75
Upper Center Phase to Lower Center Phase		
Upper Right Phase to Lower Right Phase		
Upper Left Phase to Lower Left Phase		
(d) Lowest Conductor to Closest Underbuild Phase		

[1] If Double Circuit Single Pole, Dimensions will be for One Side of Structure Only.

[2] Not Applicable for Structure with 3-Phase Circuit in a Horizontal Plane.

21.

CONDUCTOR SEPARATION AT MIDSPAN	Separation In Feet	
Avg. Span = 380 Ft., Max. Span = 590 Ft.	Average Span	Maximum Span
(a) Normal - Transmission to OHGW @ 60°F	12.62	16.32
(b) Normal - Transmission to Underbuild @ 60°F	- - -	- - -
(c) Iced Transmission to Bare Underbuild @ 32°F	- - -	- - -
(d) Iced OHGW to Bare Transmission @ 32°F	9.30	8.31
(e) Ratio of OHGW to Conductor @ 60°F Final *	0.513	0.513

* Unitless Quantity

22. Wind Pressure for Insulator Side Swing:

(a) Pounds per Sq. Foot on Bare Conductor 9 = 0.6435 Lb/Ft.

(b) Pounds per Sq. Foot on ______ inch iced conductor ________

23. Allowable Angle of Swing for Insulator Strings:

Type of Structure	No. of Ins. Units	Maximum	Normal	Minimum	Negative
TH-1AM	7	57.1°	28.5°	- - -	- - -

24. Insulator Design Loading:

(a) Suspension Insulators

Class 52-3 (Tangent)

Maximum Load Allowed 6,000 Lbs.

ANSI M&E Rating 15,000 Lbs.

Class 52-3 (Angle)

Maximum Load Allowed 6,000 Lbs.

ANSI M&E Rating 15,000 Lbs.

Class 52-5 (Deadend)

Maximum Load Allowed 10,000 Lbs.

ANSI M&E Rating 25,000 Lbs.

(b) Pin or Post Insulator Maximum Cantilever Design Load - - - Lbs.

25. Phase Arrangement: (See Structure Drawings and Plan and Profile Notes)

26. Conductor Vibration Data:

(a) Should vibration dampers be used to prevent conductor damage?

NO

(b) If yes to (a), how many are required? ____________

(c) Type of armor rods ____________

(d) Records of galloping conductor (attach).

27. Weather Data:

(a) Temperature Range (°F): Min. -13^{o} Max. 104^{o}

(b) Icing Condition: Maximum Radial Thickness 1/2 - 3/4 inches

(c) Sleet Storms: Number of days per year ______

(d) Maximum hoarfrost on conductor ______ inches

(e) Maximum height of snow on ground under conductor ______ feet

(f) Rainfall per year 12 inches

(g) Annual Storm Days 45-50/year

(h) Atmospheric contamination (describe below in remarks):

(i) Wind Velocity: Annual Mean Speed = 8 mph

(1)

Strongest (5 minute) maximum for year:	MPH
a. 19 ____	
b. 19 ____	
c. 19 ____	
d. 19 ____	

(2)

Percent time wind blows:	Percent
a. 1 to 3 MPH	
b. 3 to 8 MPH	
c. 8 to 15 MPH	
d. 15 to 30 MPH	

(j) Prevailing wind direction West to East (Annual Mean)

28. Average Terrain of Right-of-Way:

(a) Describe Briefly:

Flat to gently rolling terrain. Mostly pasture with some flood irrigation farmland.

(b) Character of Soil: Sandy

(c) Soil Bearing Value ______ lbs./sq.in. average

(d) Number of Rock Holes NONE

(e) Construction in Swamps (if any) NONE Miles

(f) Depth of Ground Water Level ______ Feet

(g) Frost Line Depth ______ Feet

(h) Remarks:

(i) Accessibility by Roads, etc. (Describe):

Centerline is accessible from established county roads.

(j) Width of Right-of-way ______ Feet

(k) Estimated Structure Footing Resistance 10 Ohms

(l) Right-of-Way Clearing (approx.) one Miles

(m) Underground Corrosion (Describe):

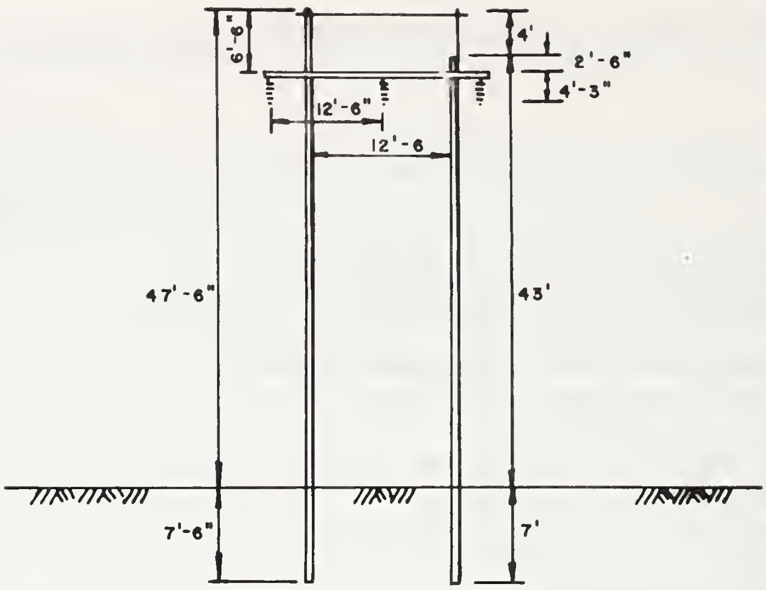
None Reported.

(n) Underground Stray Currents (Describe):

None Reported.

Items Normally Required For Transmission Line Specifications:

ITEM	CHECK
(a) Description of Units, Specifications and Drawings for Transmission Line Construction	
(b) Transmission Line Design Data Summary	
(c) Vicinity and Key Maps	
(d) Plan and Profile Drawings	
(e) Arrangement of Guys	
(f) Arrangement of Lines and Overhead Ground Wire Around Substations	
(g) Phasing Diagram	
(h) Single Line Diagram	
(i) Sag Template	
(j) Tables for Stringing Sags and Tensions	
(k) Structure List	
(l) Insulator Swing Charts	
(m) Comparative Cost Data Per Mile	
(n) Justification for Underbuild	
(o) Copy of Detailed Design Calculations	



TH-1AM

NORMAL TANGENT SPAN ON LEVEL GROUND

STRUCTURE TYPE: MODIFIED H-FRAME
POLE: 50' CLASS 3
CONDUCTOR: 477 26/7 ACSR HAWK

HEIGHT OF LOWEST COND. ABOVE GROUND = 36.25
GROUND CLEARANCE + 1 FT. = 25.00
SAG IN LEVEL GROUND SPAN = 11.25

SAG IN 380 FT. RULING SPAN @ MAX. TEMP. FINAL = 8.15

SPAN = SQUARE ROOT OF (11.25 X 380 X 380 ÷ 8.15) = 446.46 FT.

SAG AND TENSION DATA

Prepared For Heavy Loading Zone

3/8" H.S. Steel
Area = 0.07917
Ultimate = 10,800 Lbs.

Span = 380.0

Design Points				Final			Initial	
Temp.	Ice	Wind	Sag	Ten.	P/Ult.	Sag	Ten.	P/Ult.
0	1/2 In.	4+.30	5.97	3712	34.37	5.97	3712	34.37
32	1/2 In.	No Wind	5.06	2881	26.68	4.86	2999	27.77
-20	Bare	No Wind	1.82	2712	25.11	1.69	2911	26.95
0	Bare	No Wind	2.00	2466	22.83	1.83	2700	25.00
							*	*
60	Bare	No Wind	2.76	1788	16.55	2.37	2079	19.25
32	Bare	No Wind	2.36	2090	19.35	2.08	2365	21.90
90	Bare	No Wind	3.28	1502	13.91	2.76	1789	16.56
120	Bare	No Wind	3.90	1266	11.72	3.23	1526	14.13
140	Bare	No Wind	4.34	1136	10.52	3.60	1370	12.69
167	Bare	No Wind	4.96	994	9.21	4.15	1189	11.01
212	Bare	No Wind	5.99	824	7.63	5.13	961	8.90

Prepared For Heavy Loading Zone

477 26/7 ACSR Hawk
Area = 0.43560
Ultimate = 19,430 Lbs.

Span = 380.0

Design Points Creep is a Factor Temp.	 Ice	 Wind	 Sag	 Final Ten.	 P/Ult.	 Sag	 Initial Ten.	 P/Ult.
0	1/2 In.	4+.30	6.01	5781	29.75	5.98	5819	29.95
32	1/2 In.	No Wind	6.19	4387	22.58	5.83	4652	23.94
-20	Bare	No Wind	2.77	4288	22.07	2.55	4642	23.89
0	Bare	No Wind	3.30	3589	18.47	2.91	4080	21.00
							*	*
60	Bare	No Wind	5.38	2205	11.35	4.46	2660	13.69
32	Bare	No Wind	4.36	2719	13.99	3.64	3255	16.75
90	Bare	No Wind	6.46	1837	9.46	5.44	2183	11.24
120	Bare	No Wind	7.40	1606	8.26	6.43	1846	9.50
140	Bare	No Wind	7.72	1539	7.92	7.08	1678	8.64
167	Bare	No Wind	8.15	1459	7.51	7.91	1501	7.73
212	Bare	No Wind	8.85	1343	6.91	8.80	1351	6.95

VERTICAL SPAN LIMITED BY CROSSARM STRENGTH

1 Tangent Structures

Modified H-Frame 26 Ft. Arm
Wood Species is: Douglas Fir
Fiber Stress is: 8000 psi
Safety Factor = 4
Number of Arms used in Calculations = 1
X-Arm Cross Section: Width (5 3/8"), Depth (7 5/8")
1/8" will be subtracted from the above dimensions

Max. Bending Moment = (Fiber Stress w/S F.)(Width) x (Depth * * 2)/(6)

= 2000.0 x 1 x 5.250 x 7.500 x 7.500/6

= 98437.6 In.-Lbs.

Vertical Span = ([Moment/Lever Arm] - Ins Weight) / Cable Weight with Ice

= ([98437.6 / 7.50] - 78.0) / 1.50120

= 822.3 Feet (Use Maximum Temperature Curve)

SPAN LIMITED BY CONDUCTOR SEPARATION

1 Tangent Structure : Modified H-Frame

Horrizontal Separation = (0.025) (kV) + (F) (Sq.Root[60° Sag]) + (.71) (Ins Length)

12.50 = 0.025 (115.0 kV) + 1.25 (Sq.Root[60° Sag]) + 0.71 (3.93)

60° Final Sag = 29.90

Maximum Span = Sq.Root(380 x 380 x 29.90/5.38)

= 895.9 Feet

CONDUCTOR-SEPARATION-AT-MIDSPAN

Structure Type Modified H-Frame
OHGW = 3/8 H.S. Steel
Conductor = 477 26/7 ACSR (Hawk)
Ruling Span = 380

1. Normal Transmission to OHGW @ 60° Final

380 Average Span

OHGW Sag	=	(-)	2.76
Transmission Sag (Bare)	=	(+)	5.38
Separation at Support	=	(+)	10.00
Midspan Separation	=		12.62 Ft.

590 Maximum Span

OHGW Sag	=	(-)	6.65
Transmission Sag (Bare)	=	(+)	12.97
Separation at Support	=	(+)	10.00
Midspan Separation	=		16.32 Ft.

2. Iced OHGW to Bare Transmission @ 32° Final

380 Average Span

OHGW Sag	=	(-)	5.06
Transmission Sag (Bare)	=	(+)	4.36
Separation at Support	=	(+)	10.00
Midspan Separation	=		9.30 Ft.

590 Maximum Span

OHGW Sag	=	(-)	12.20
Transmission Sag (Bare)	=	(+)	10.51
Separation at Support	=	(+)	10.00
Midspan Separation	=		8.31 Ft.

The Ratio of OHGW/Transmission Conductor @ 60° Final is:

= 0.5130 for all span lengths

MW = Moment Due to Wind on Wires
MP = Moment on Pole
MR = Maximum Allowable Moment at Ground Line
SPAN = Sum of Adjacent Spans Allowed

MW = Sum from Top to Ground of (Height Above Ground) x (Number of Wires) x (Transverse Wire Force Wh)

MP = ([Force of Wind] x [Height of Pole Above Ground Squared] x [2xTop Dia. + Ground Line Dia.])/72

MR = .000264 x Fiber Stress = The Cube of the Pole Cir. at Ground Line

SPAN = 2 x ([MR/Safety Factor] - MP)/MW

Structure Type/Description: Modified H-Frame

Pole Type Is: Douglas Fir or S.Y.P.
Pole Class Is: 3
Pole Safety Factor Used: 4
Pole Buried Standard Depth + (0) Feet
Heavy Loading Zone
Wire Sizes Are: 3/8 H.S. Steel, Hawk
Bayonets Are Used

Pole Height	Dia. Gnd. Line	MW	MP	MR	SPAN
20	8.78	16.90	333.1	44,265.1	1,270
25	9.50	21.52	536.5	56,127.8	1,254
30	10.25	26.72	829.9	70,429.7	1,256
35	10.82	31.91	1,189.8	83,007.8	1,226
40	11.46	37.69	1,676.3	98,550.6	1,218
45	11.88	42.89	2,183.8	109,729.0	1,177
50	12.30	48.09	2,767.3	121,795.0	1,151
55	12.72	53.29	3,429.8	134,786.0	1,136
60	13.15	58.48	4,174.4	148,767.0	1,129
65	13.57	63.68	5,003.5	163,664.0	1,128
70	13.84	68.88	5,888.6	173,724.0	1,090
75	14.27	74.08	6,891.2	190,298.0	1,098
80	14.55	79.28	7,946.0	281,591.0	1,071
85	14.83	84.48	9,096.6	213,438.0	1,048
90	15.10	89.67	10,313.7	225,640.0	1,028
95	15.39	94.87	11,631.0	238,479.0	1,012
100	15.67	100.07	13,039.1	251,763.0	997
105	15.95	105.27	14,539.7	265,480.0	985
110	16.23	110.47	16,137.0	279,904.0	975
115	16.51	115.67	17,829.7	294,685.0	966
120	16.64	120.87	19,529.4	301,922.0	926
125	16.93	126.06	21,414.9	317,599.0	920

INSULATOR SWING CALCULATIONS

MAX = Maximum Allowable Swing Angle
NOR = Normal
MIN = Minimum
NEG = Negative
H = Horizontal Span (Assumed Values)
V = Vertical Span Values (Calculated)
T(167F) = Tension, 167 Deg. Final, Bare Cond. = 1,459.0 Lbs.
T(60F) = Tension, 60 Deg. Final, Bare Cond. = 2,205.0 Lbs.
T(-20I) = Tension, -20 Deg. Initial, Bare Cond. = 4,642.0 Lbs.
WH(Wind Force) = 9.0 Lb./Sq.Ft. = 0.64320 Lb./Ft.
WV = Weight Per Foot of Bare Conductor = 0.65680 Lb. S/Ft.
Dia. of Conductor = 0.85760 In.
WI = Weight of Insulator String
ANG = Deflection Angle on Structure at PI Location

Maximum Swing Formula:

$$V = \frac{\dfrac{[2 \times T(-20I) \times SIN(ANG/2)] + (H \times WH)}{TAN(MAX)} - (WI/2)}{(WV)}$$

Normal Swing Formula:

$$V = \frac{\dfrac{[2 \times T(60) \times SIN(ANG/2)]}{TAN(NOR)} - (WI/2)}{(WV)}$$

Minimum Swing Formula:

$$V = \frac{\dfrac{[2 \times T(167F) \times SIN(ANG/2)] - (H \times WH)}{TAN(MIN)} - (WI/2)}{(WV)}$$

Negative Swing Formula:

$$V = \frac{\dfrac{[-2 \times T(167F) \times SIN(ANG/2)] - (H \times WH)}{TAN(NEG)} - (WI/2)}{(WV)}$$

Structure Type	No. of Ins	MAX.	NOR.	MIN.	NEG.
Modified H-Frame	7	58.10	28.50	0.00	0.00

MAXIMUM FORMULA : (COLD CURVE) MAX = 58.1 Degrees WI =

78 Lbs. For Modified H-Frame

Normal Formula : (60F) NOR = 28.5 Degrees

VERTICAL SPAN

	(------	------	------	------	HORIZONTAL SPAN	------	------	------	------	------)
Degrees	NOR.	200	300	400	500	600	700	800	900	1000
0.00	-59	63	123	184	245	306	367	428	489	550
0.50	-5	101	162	223	284	345	406	467	528	589
1.00	49	139	200	261	322	383	444	505	566	627
1.50	102	178	239	300	361	422	482	543	604	665
2.00	156	216	277	338	399	460	521	582	643	704
2.50	210	254	315	376	437	498	559	620	681	742
3.00	264	293	354	415	476	537	598	659	720	780
3.50	318	331	392	453	514	575	636	697	758	819
4.00	372	370	431	492	552	613	674	735	796	857
4.50	426	408	469	530	591	652	713	774	835	896
5.00	480	446	507	568	629	690	751	812	873	934

69 KV TRANSMISSION LINE
TS-1 1/0 6/1 500 Ft. Ruling Span 1952

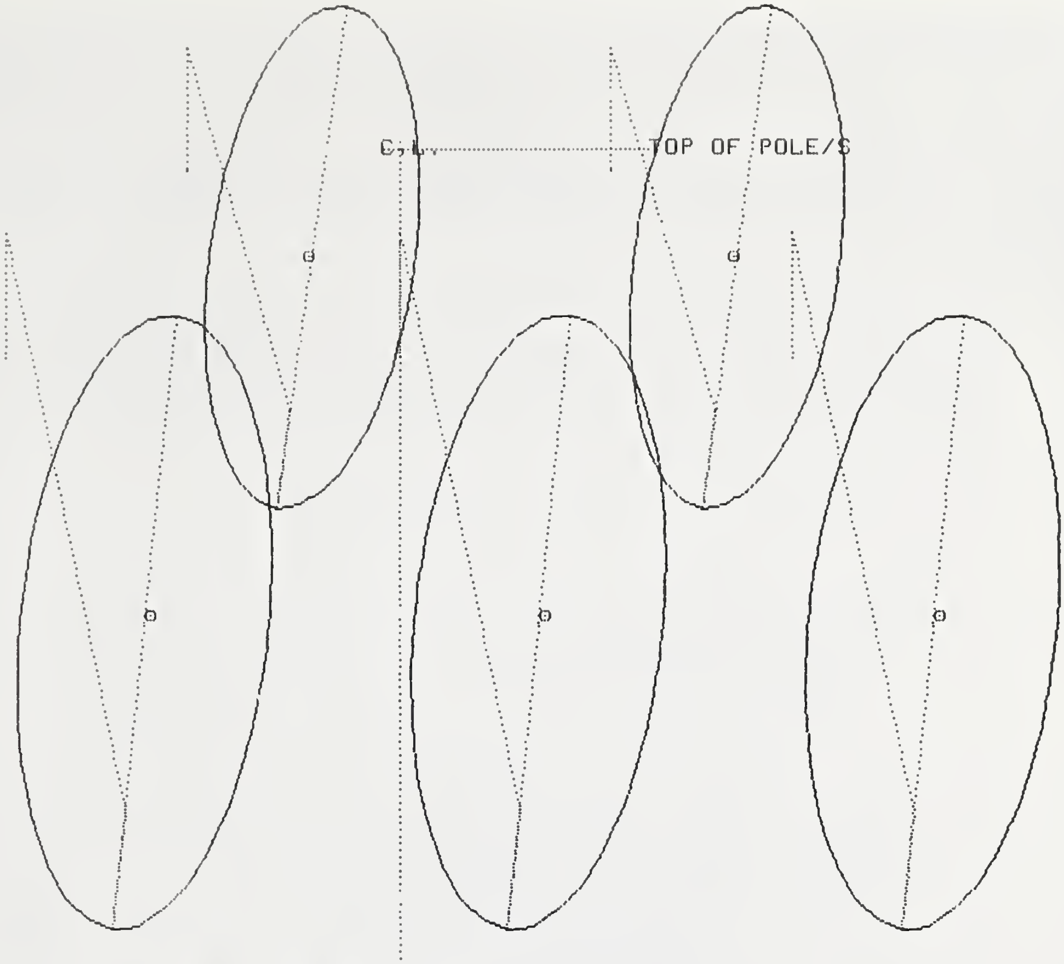
Station No. - 58207
Sum of Spans = 57945
The Cube of the Spans = 8036988038.5
Longest Span = 590
Shortest Span = 201
Average Span = 362.15625
The Actual Ruling Span is = 372.425

Station No. - 60903.6015625
Sum of Spans = 2697
The Cube of the Spans = 410138328
Longest Span = 448
Shortest Span = 339
Average Span = 337.125
The Actual Ruling Span is = 389.964

Station No. - 130768
Sum of Spans = 70065
The Cube of the Spans = 9872838406
Longest Span = 437
Shortest Span = 260
Average Span = 370.7142857142857
The Actual Ruling Span is = 375.38

Station No. - 175272
Sum of Spans = 44104
The Cube of the Spans = 6129378527
Longest Span = 445
Shortest Span = 206
Average Span = 364.495867768595
The Actual Ruling Span is = 372.794

Station No. - 182178
Sum of Spans = 6806
The Cube of the Spans = 998855518
Longest Span = 443
Shortest Span = 305
Average Span = 358.2105263157895
The Actual Ruling Span is = 383.094



FOR SPAN LENGTH OF 590 FEET
SINGLE LOOP LISSAJOUS ELLIPSE PATTERN
STRUCTURE:MODIFIED H-FRAME

DATA_TABLE_FOR_WIRE_CODEWORD_3/8" H.S.STEEL

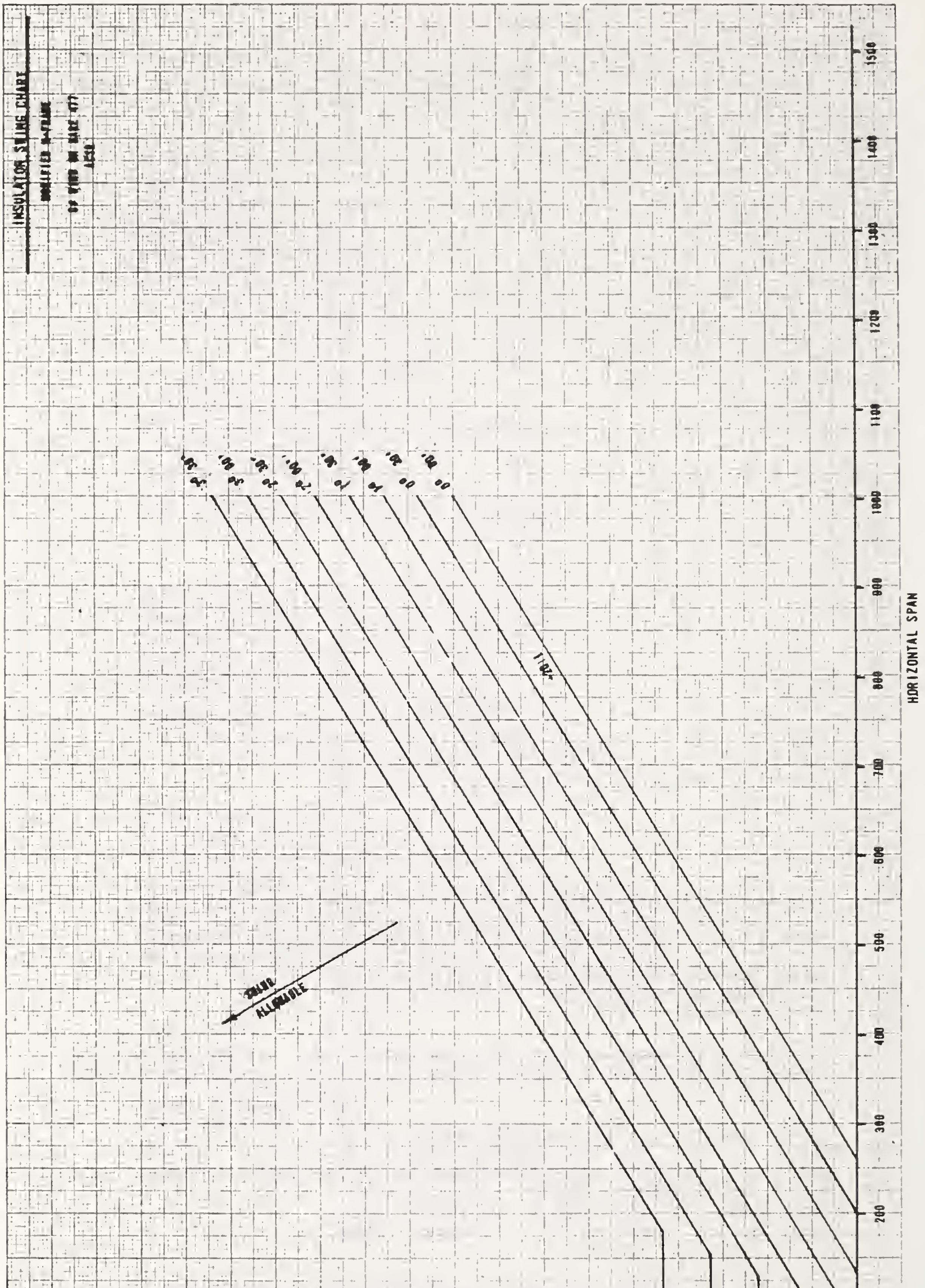
ANGLE= 15.672537 AND ANGLE+ANGLE/2= 23.508806 DEGREES
A + E = 12.197964 FEET
MAGNITUDE OF MAJOR AXIS = 16.247455 FEET
MAGNITUDE OF MINOR AXIS = 6.498982 FEET
B = 3.049491 FEET

POINT OF ATTACHMENT= -3.25 DOWN AND 6.75 FROM CENTER LINE
POINT OF ATTACHMENT= -3.25 DOWN AND-6.75 FROM CENTER LINE

DATA_TABLE_FOR_WIRE_CODEWORD_HAWK

ANGLE= 11.652755 AND ANGLE+ANGLE/2= 17.479133 DEGREES
A + E = 18.851455 FEET
MAGNITUDE OF MAJOR AXIS = 19.652519 FEET
MAGNITUDE OF MINOR AXIS = 7.861008 FEET
B = 3.730504 FEET

POINT OF ATTACHMENT= 2.75 DOWN AND 12.5 FROM CENTER LINE
POINT OF ATTACHMENT= 2.75 DOWN AND 0 FROM CENTER LINE
POINT OF ATTACHMENT= 2.75 DOWN AND-12.5 FROM CENTER LINE

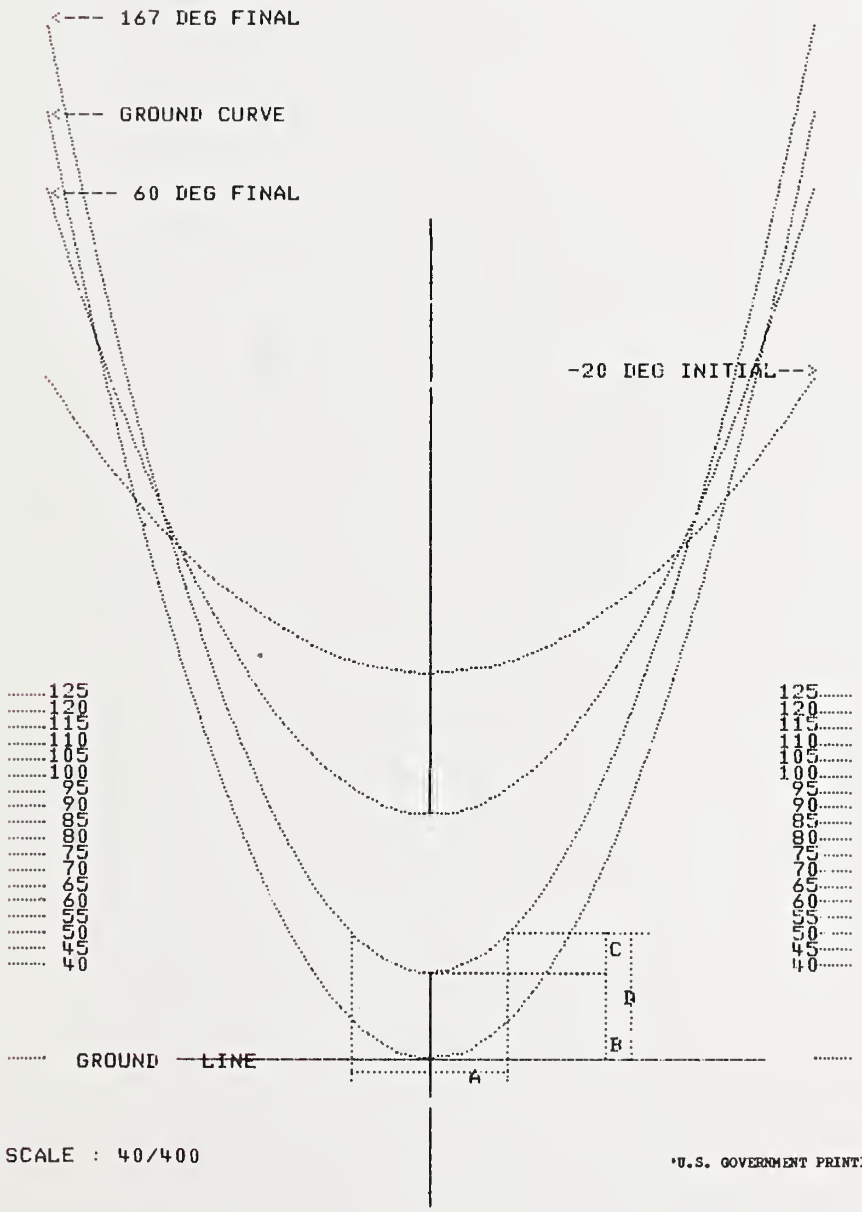

INSULATOR SWING CHART
ALLOWABLE
HORIZONTAL SPAN
VERTICAL SPAN
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500

MODIFIED-H FRAME

477 26/7 ACSR HAWK   380 FT RULING SPAN   115.00 KV   HEAVY LOADING ZONE   50/3   POLE
MODIFIED H-FRAME   STRUCTURE   MAXIMUM DESIGN TENSION= 5819 LBS(29.95 '/.)
0 DEG INITIAL TENSION= 4080 LBS(21.00 '/.)   ULTIMATE STRENGTH = 19430 LB.S

A.	LEVEL GROUND SPAN =	446.5
B.	GROUND CLEARANCE =	25
C.	SAG IN L.G. SPAN =	11.25
D.	HT. ABOVE GR. OF LOWEST COND =	36.25
E.	DIST. FROM POLE TOP TO COND =	6.75

SAG TEMPLATE



SCALE : 40/400

International System of Units

In December 1975, Congress passed the "Metric Conversion Act of 1975." This Act declares it to be the policy of the United States to plan and coordinate the use of the metric system.

The metric system, designated as the International System of Units (SI), is presently used by most countries of the world. The system is a modern version of the meter, kilogram, second, ampere (MKSA) system which has been in use for years in various parts of the world.

To promote greater familiarization of the metric system in anticipation of the U.S. converting to the system, REA is including metric units in its publications. This bulletin has, therefore, been prepared with the International System of Units (SI) obtained from ANSI Z 210-1976 - Metric Practice. Approximately equivalent Customary Units are included to permit ease in reading and usage, and to provide a comparison between the two systems.